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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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Proof Wanted.

In many foundries it is taken that it is quite possible to separate charges in the cupola, and it is accepted that a double charge of coke provides an adequate method of preventing the contamination of a mixture suitable for high-grade cylinder work by ordinary grey-iron mixtures for jobbing work. Excepting for very small cupolas, conclusive evidence has been given that coke as a means for separating charges is useless. For instance, at the last conference of the American Foundrymen's Association, Dr. Moldenke detailed trials he had made for the purpose of definitely establishing the hopelessness of trying to separate mixtures by a double layer of coke in the cupola. For this purpose, it will be remembered, he used two mixtures, one containing nickel and chromium and the other free from these elements, yet the resultant metal showed the metal which should have been free from special elements was contaminated by them and the special mixture was low in both nickel and chrome content. Nickel and chromium, in their elementary condition, have quite high melting points, yet their migration was strongly noticeable. Phosphorus and sulphur, which, of course, are not present in the elementary state, but as phosphides and sulphides respectively, have an infinitely better chance of migrating than chromium and nickel. Two identical cases have been noted, one by Mr. Matt. Riddell and the other by Mr. W. H. Poole, where the phosphide eutectic has left cast-iron boxes used for case-hardening and been found amongst the contents of the box, yet the box has been unaltered to all intents and purposes. If such cases come to light in connection with heat treatment furnaces, obviously the same phenomenon has a much better chance of taking place in the cupola. Sulphur, too, has every chance of migrating in the cupola, and it is essentially this element and phosphorus which require rigid control in foundry practice. Now, that proof has been forthcoming, of the difficulty, if not the impossibility of separating charges in the cupola, the foundry world has a right to expect those foundrymen who assert that they *can* separate charges in the cupola, should publish concrete proof of their assertions. It is suggested that all materials for each charge should be analysed and checked by a disinterested laboratory, the usual melting losses ascertained for the plant. All other factors should be stated, especially the nature of the fuel and fluxes. If this is done, it will show whether migration can be prevented or not. If the latter, data as to the relative migratory powers of the carbon, silicon, manganese, sulphur and phosphorus should be forthcoming, at least for the conditions prevailing at the foundry conducting the experiment. If the migratory power possessed by the various constituents which go to make up cast iron, is established, then an arrangement of charging might be evolved, incorporating compensatory mixtures, which would accomplish the purpose now inadequately served by a double charge of coke. Foundrymen should realise that if a sleeve of high carbon impure steel is sweated on to a cylinder of pure iron and the composite bar is heated to redness, maintained there for a few hours, cooled down and analysed, it will be found that all the elements have migrated, *in the solid*, from the impure steel sleeve to the pure iron core, resulting in a relatively homogeneous mass. Whilst this last example is merely given as a point of interest, it illustrates that the migration of elements is a subject of basic interest to foundrymen, and when studying their cupola practice they should make themselves *au fait* with all aspects of the subject.

Iron and Steel Output in March.

The National Federation of Iron and Steel Manufacturers report that the production of pig-iron in March totalled 633,600 tons, the highest monthly production attained since January, 1921 (642,100 tons). The furnaces in blast at the end of the month numbered 202, an increase of 13 during the month. The production includes 206,300 tons of hematite, 204,600 tons of basic, 144,700 tons of foundry, and 45,900 tons of forge pig-iron.

The output of steel ingots and castings in March totalled 802,500 tons, which is the highest output attained since September, 1920, when the production amounted to 884,700 tons.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Physics of Cast Iron.

To the Editor of The Foundry Trade Journal.

Sir,—Your issue of March 29 contained the above Paper by Mr. E. Adamson. With your kind permission I desire to make the following comments:—

Firstly, this Paper is very similar to another Paper read by the same author before the Manchester Association of Engineers on March 9, and entitled "Carbon in Cast Iron."

I feel there are two main themes, firstly, Mr. Adamson's tendency to camouflage the fact that cast iron contains a great number of elements other than carbon, and, secondly, his desire to convince us that the opinions expressed by him in the past are now proved correct.

Admittedly is this last statement distasteful, but nevertheless it is too evident to be ignored. The following passages speak for themselves:

"In 1906 the author stated . . . . the difference in these two curves was purely the difference in primary temperatures, but the significance *did not appear to be understood.* Again, in 1912, the author stated. . . . In 1906, and even in 1911, the writer was looked upon as unorthodox, to use a mild term, but the fact that . . . . *is sufficient proof of the correctness of his early statements. No doubt the chemist . . . . will perhaps now realise that the chemistry of cast iron,* whilst necessary, *is the minor and not the major part of the study of this science.*"

Satirically viewed, the above statements tell us that, owing to Mr. Adamson, the chemist has at last realised the folly of his ways and of his profession, which he did not do in 1906, nor even in 1911, in spite of the fact that Mr. Adamson told him about it. For my own part I have not seen sufficient proof of the correctness of the majority of Mr. Adamson's early statements or of his present ones.

The first matter of interest in his Paper appears to me to be the following:—

"The above are bare statements of fact, but it is not proposed to give any detailed reasons, *except in the case of carbon, which controls the molecular physics of cast iron as disclosed by the fracture.*"

Knowing as I do that the fracture of cast iron discloses *to Mr. Adamson* many things which are a closed book *to me*, I am unable to accept his statement that all *he sees* is due to carbon, and I know of other elements which have their effect upon the molecular physics of cast iron as disclosed by the fracture *as I see it.*

I admit that I may be dull, but Mr. Adamson's use of Moissan's work to prove his own theories may be satisfactory to him, but, personally, I fail to see the connection and find the matter distressingly obscure.

Mr. Adamson says that "close-grain" iron and "open-grain" iron are produced under low and high temperature conditions respectively; but whilst that may be true in the particular sense, it does not follow and it is not true that grain cannot be closed save by the employment of low-temperature pig-iron or that the grain is never close save in low-temperature irons.

A further sentence says: "The smaller the formation of graphite in cast iron, the closer the fracture and the stronger the iron . . . probably no one will dispute this statement." I think a more careful and impersonal method of saying this would be that the closer the fracture and the stronger the cast iron the smaller the formation of graphite.

With respect to curves A and B, Mr. Adamson states that the silicon, phosphorus, sulphur, and manganese were practically the same in each iron, and he leaves us to assume that the two irons are those he has mentioned in past years. Assuming this, I can make no remark other than that if Mr. Adamson thinks that an iron containing more than twice as much manganese as another iron is *practically the same*, I no longer wonder why he sees so little in the control of cast iron by its composition. According to those curves it follows that sample A, when molten, must have contained about 1 per cent. of undissolved graphite or else that that amount of graphite had been lost or was never present.

If one of my own assistants brought this curve to me I should say: "Please repeat the experiment at least three times. Also try a series of quenching or chilling experiments. Also in every case analyse the metal before and after melting. I can pass no opinion at the moment because the investigation as it stands is incomplete and inconclusive."

I have found that, after heating to 1,000 deg. C., the pearlite transformation of semi-steel is somewhat different from that of a cast iron of similar composition; whereas in comparing one cast iron with another cast iron under similar conditions of test, the pearlite transformation appears to be affected by the silicon and manganese, and not at all by the carbon, phosphorus, and sulphur.

Mr. Adamson quotes other phenomena which have come before his notice, but the details are too few and vague for comment. I think in many cases he attempts to argue from the particular to the general.

In a final paragraph Mr. Adamson says "Structure itself is sub-divided, *for in addition to the varying percentages of impurities*, even a fine structure may be what a practical man calls 'dry,' and not, therefore, so strong as another iron of apparently the same structure." *In addition to what?* may I ask.

Also, if two irons have *apparently the same structure* and a practical man calls one of them "dry," why should he call the other one anything different?—Yours faithfully,

Horace J. Young, F.I.C.

16, Ashfield Grove,
Whitley Bay.

Machine Moulding Methods.

To the Editor of The Foundry Trade Journal.

Sir,—Our notice has been drawn to reference made by Mr. Hardyman in his reply to questions at a meeting of the Institution of Production Engineers, and as reported in your current issue. Mr. Hardyman states that with regard to the sand-slinging machine there were two objections; one was in keeping the facing sand in position on the pattern, and the other was that there was similar finishing off to do in ramming the final stages of the box, and hand-scraping it off, as there was with the jar machine.

Neither of these statements is correct, and are most misleading. The sand-slinger machine can be utilised with fine facing sand, and the final ramming of the mould is done without any auxiliary means than the impact from the sand-slinger head. It is not necesary to hand-scrape the surface of the mould, as ramming can be so arranged as to give a perfectly flat surface if desired.—Yours, etc.,

For Foundry Plant & Machinery, Limited.
Daniel Sharpe, *Manager.*

28, Royal Exchange Square, Glasgow.
April 11.

American Foundrymen's European Trip.

The latest news from the States indicates that the members of the American Foundrymen's Association will sail on the *Leviathan* from New York on August 18, arriving Southampton on August 24. On Saturday, August 25, they will be the guests of the London Branch of the I.B.F., associated with other societies.

Mr. J. G. S. Primrose has joined the metallurgical staff of Messrs. Richard Johnson and Nephew, Limited, of Bradford, Manchester.

The Pneulec Machine Company, Limited, manufacturers of moulding machines and other foundry equipment, have just completed the building of their new works at Smethwick, near Birmingham. It now possesses one of the most complete foundry equipment shops in the country.

Notes on Malleable Iron Production.*

By W. H. Poole, M.I.Brit.F.

In this Paper it is proposed to deal essentially with Reaumur-type malleable iron. This is known generally as white-heart malleable, as distinct from black-heart. This latter type is that mainly produced in America, though there are a few firms making black-heart here, notably Messrs. Leys, of Derby.

Without entering deeply into the historical data on malleable-iron production, it is to the work of the celebrated French savant that we owe the wonderful treatise on "The Softening of Cast Iron."

Fig. 1.—General view of coal-fired annealing ovens, in which direct firing is used. Note the firebrick jacket around the iron packing pans. This gives added life to annealing pans.

In 1722 he published his work on the art of converting iron into steel and softening "cast iron."

Reaumur was a wonderful man with an amazing diversity of thought and action. He gave the world his thoughts on the study of animal life, work on mathematics and physics, and, particularly interesting to founders and engineers, his work on malleable iron.

The present practice of white-heart or Reaumur malleable iron is carried out now on much the same lines as indicated by Reaumur so many years ago. An Englishman, Samuel Lucas, in 1804 obtained a patent for this process, and it is from this date that the practical application to the arts was developed.

In 1769 J. Ashton, of Birmingham, obtained a patent for softening cast iron in a slow fire, and in 1783 George Matthews also obtained a patent for softening castings, such as guns, etc., by this process. This latter patent was perhaps the beginning of the Blackheart malleable iron production.

It is of much interest to note that Reaumur experimented with many packing media. He found that "heating cast-iron castings embedded in red oxide of iron softens the metal perfectly and more rapidly than all the other matters tried." To-day hematite ore is in use as a packing medium.

Materials Employed in Malleable Iron Production.

The pig-iron used differs in many essentials from that employed in ordinary grey-iron work. The bulk of pigs used, though obviously not all, can be classed in the hematite type, that is, made in furnaces making hematite. The analysis of this iron shows it to contain low phosphorus and manganese content. The importance of this will be explained later.

The classification and usage of malleable iron pigs must be made to a fine limit—and the importance of a combination of fracture and analysis-grading is fully demonstrated in malleable-iron work. It will be noted that this much-discussed point is mentioned, and personally the author finds much of value from both the fracture and the analysis—the one, without the other, giving results oft-times misleading. By analysis silicon control is not meant essentially but a full consideration of all the elements.

The selection of the most suitable pigs is largely a matter of the type of work in hand. Generally speaking, a stock of white, mottled, and grey pigs is sufficient for ordinary needs.

Scrap.—One very vital point is the need for control to fine limits of the resultant cast-metal analysis. The scrap control, therefore, assumes a much more serious aspect than with grey-iron work. This will be dealt with in the question of mixing.

Coke.—When cupola-melting is practised, it is very essential to have a clean, hard type of coke of good physical properties. Here much trouble is caused in the cupola process.

Ore.—As stated, hematite ore is used generally as a packing medium, and the need for having this material to a specification should be emphasised, especially with reference to certain likely impurities. The specification suggested is: Fe_2O_3, 80 to 90 per cent.; SiO_2, 10.0 per cent.; FeO, 1.5; CaO, 1.0 to 1.5; Al_2O_3, low; water, 5.0; and MnO, less than 1.0 per cent.

The ore must be free from all fusible portions, lime compounds particularly being injurious. It will be noted that emphasis is made on the MnO content. Manganese compounds are often found in veins or small particles of MnO_2, as light brown carbonate, associated with calcspar and as pyrolusite. This should be kept in mind when the pitting defects are considered.

Moulding sands will not be very fully considered, but for some classes of malleable-iron work, such as thin pipe fittings, the sand selection plays an important part.

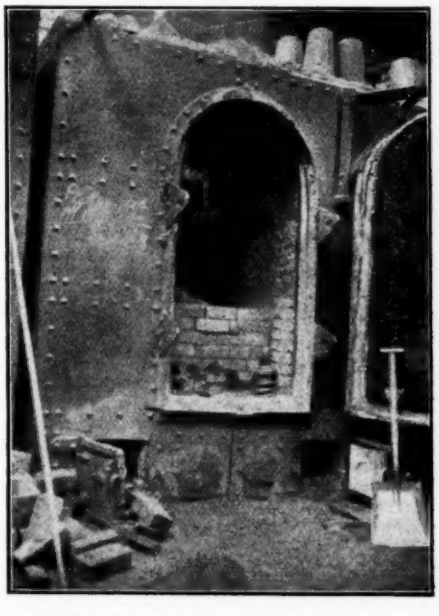


Fig. 2.—Shows a case oven in which no annealing pans are used. The castings are sealed in the case, the fire circulating around this.

Melting Practice.

A brief consideration of the various melting units is now given: (1) Crucible—pit fired (coke) mainly; (2) cupola; (3) Siemens; (4) air furnace; and (5) converter furnace.

Crucible.—All the above types have been used for malleable-iron melting, in this country the crucible and cupola being mainly employed. Economic consideration naturally favours the cupola over the crucible, the advantage of the crucible working being in the better melting conditions. In this method the metal is not in contact with the fuel, so that there is less sulphur absorption, as well as

* A Paper presented to the London Branch of the Institute of British Foundrymen.

a difference in the actual melting condition. Very excellent results can be obtained from pot work, as is shown by the samples submitted.

Siemens.—During the war the author had the pleasure of inspecting work turned out by a Yorkshire firm from a small Siemens furnace, and some really excellent metal resulted.

Air Furnace.—For a large output, such as in the States, these latter types are good. It is possible to sample readily and alter the metal condition before tapping. The use of steel in the mix can be made, and the author has seen some fine metal from a steel-mix, melted in an air furnace.

Cupola Metal.

The first vital point is so to mix and cast the metal, that the casting "as cast" in any section must show a white fracture and a metal free from graphitic carbon. The first stage, therefore, is in the production of the white-iron casting. In this state, if success is to be obtained in the next annealing operation, the whole of the carbon must be in the form of combined carbon or cementite (Fe_3C). A typical analysis of a white-iron casting is: T.C., 3.0 to 3.25 per cent.; C.C., 3.0 to 3.25; Gr., nil or trace; S., 0.75; S., 0.25; P., 0.05; and Mn., 0.10 per cent.

The sulphur content should be noted, as it is in itself a factor in keeping all the carbon in the hard form. Sulphur plays an important part in malleable-iron work. The white iron as cast is very brittle, very hard, and of no service in this condition to the engineer.

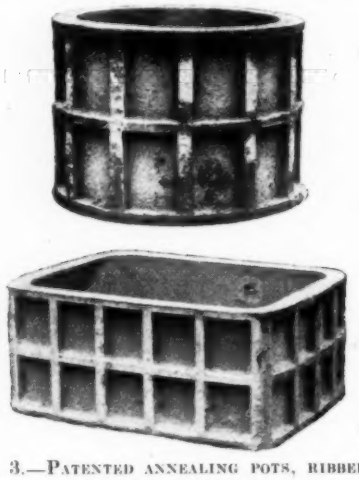


Fig. 3.—Patented annealing pots, ribbed to facilitate daubing.

Melting Practice.

As such a definite control is essential in the malleablising or annealing process, it is of vital importance so to control the mix that uniformity of analysis, etc., results. The cupola control for malleable iron requires the exercise of much thought. One part of the cast, with higher silicon than the other, will affect the anneal. In shop practice it is difficult to fully grade the sections of work cast to suit various metal mixings. It is possible with sufficient care to run a mix throughout the blow, with a silicon variation of 0.10 per cent. maximum. A typical actual example can be taken from a mixture of 30 lbs. of Distington mottled at 0.95 per cent.; 50 lbs. of H.C.M. at 0.45; 70 lbs. of H.C.M. at 0.44; and 150 lbs. of scrap at 0.51 per cent. Si. Samples taken at intervals during the blow gave 0.42, 0.44, 0.48, 0.40, 0.51, 0.48, 0.50, 0.41, 0.43, and 0.46 per cent. Si.

This necessitated a full knowledge of the furnace practice. Mottled iron was added in this case part-way through the blow. The first tap and last few charges show the maximum variation.

Too much emphasis cannot be put on the importance of furnace control. The writer takes full details of blows, air volume used, pressures, etc., when examining this melting question. Unless the "as cast" product has uniformity, the annealing is a hopeless task.

Though malleable iron has a lower melting point than grey-iron, more fuel is used in malleable-iron cupola practice, as so much more superheat is necessary due to the lighter general nature of malleable iron over grey-iron work.

The metal compositions are graded to suit the class of work. Some typical analyses are given in Table I.

Table I.—*Showing Suitable Compositions for Various Classes of Malleable Castings.*

	Motor Hub Section up to ¼ in.	Heavy Axle Bracket.	General Medium.	Small Fittings.
T.C. ...	2.83	3.20	3.18	3.0 to 3.25
CC. ...	2.83	3.15	3.18	3.0 to 3.25
Gr.	trace	0.05	trace	nil
Si	0.65	0.40	0.50	0.6 to 0.75
S	0.30	0.22	0.136	0.3 to 0.35
P.	0.017	0.03	0.01	0.01
Mn. ...	0.07	0.04	0.20	0.11

Carbon and Iron.

Pure iron melts at about 1,540 deg. C., which is about 300 deg. higher than the melting point of ordinary cast-iron. If such iron is heated in contact with carbon, it will gradually absorb more and more carbon as the temperature exceeds 900 deg. C.

Over 10 per cent. carbon can be absorbed by pure iron, if heated sufficiently high and long. As this metal cools, however, all carbon above 4.3 per cent. separates out and the residue is the solid solution (Fe_3C) in iron that can remain stable and would solidify at 1130 deg. C.

Fig. 4.—A daubed patented annealing pot.

Iron-Carbon Diagram.

Fe_3C will dissolve in iron, so that the solution is equal to 1.7 per cent. C. As this further cools, the carbon is thrown out as Fe_3C (cementite or pro-eutectoid cementite) until the carbon content of the residue is 0.9 per cent., which changes at the lower temperature of 710 deg. C into pearlite. Thus there are three stages: (1) When primary graphite above 4.3 per cent.; (2) pro-eutectoid graphite; and (3) graphite from pearlite. In malleable iron the first is not evident, therefore the graphitisation takes place by (2) and (3). Pearlitic structure is to be much desired in the final malleable iron as evidenced by stronger metal.

The point around which the process revolves is the amount and formation of the carbon. It is common knowledge that cast-iron is brittle and will stand no shock. This brittleness is due to the effective way in which the carbon in the form of graphite breaks up the structure. Apart from the amount of free-carbon present its form and shape have very considerable influence on the strength of the finished product.

Coarse and Fine Graphite.

It is quite possible to have a casting with a high free-carbon content in a very fine condition, which is tougher than one with a lower free-carbon content in a much coarser form.

The strength of a chain is determined and

governed by its weakest link. This principle is true for all cast-iron, the free-carbon being the links in this case. It can readily be seen that the smaller the carbon nodules the greater support they get from their much stronger and more ductile neighbour, the iron, in proportion. Hence it is evident that the finer the free-carbon formation is produced, the better the result.

If malleable castings could be made from pure iron and pure carbon the process would be very much simplified, but unfortunately it is not possible on a commercial scale to obtain raw materials sufficiently pure for this ideal case, so that the influence of other elements, such as silicon, sulphur and manganese, must be studied and accounted for. The influence of these three elements cannot be considered detrimental, and, in many cases, can be put to advantage when properly controlled. Returning to the theoretical case of iron and carbon, pure iron alone melts at about 1,530 deg. C. If an excess of carbon is available, this iron will take up at this temperature over 5 per cent. of carbon in solution, but on cooling again it will solidify at a temperature of 1,130 deg. C., throwing out on cooling excess carbon until the amount retained is 4.3 per cent., and then solidifies. When iron takes up carbon into solution, this carbon is always combined with some iron, producing a compound Fe_3C, and it is this compound of iron and carbon which dissolves in the excess iron.

It is well to note that the carbon and iron alloy which solidifies at 1,130 deg. C. is the alloy of these two elements which has the lowest melting point, and is metallurgically called the *eutectic* alloy, the word eutectic being derived from the Greek equivalent for "most fusible."

In passing, it is interesting to know that nearly all alloys containing two or more members have a eutectic alloy of definite composition and definite melting or solidifying point.

The ejection of excess carbon above 4.3 per cent. is shown when the graphite floats on the surface of the molten metal. It is generally accepted that this graphite is produced from the splitting up of the Fe_3C, which is not stable at this temperature range, namely, above 1,130 deg. C. The well-known appearance in foundries of flakey graphite is due to this phenomenon. This kind of graphite is usually known as "kish." If the carbon present is below 4.3 per cent., instead of Fe_3C being thrown out a solid solution of Fe_3C in iron is thrown out which results in the later successive portions of metal becoming richer in Fe_3C until, when solidification takes place, the percentage of carbon is 4.3 per cent. that of eutectic composition, and solidification takes place at the eutectic temperature, viz., 1,130 deg. C. This solid solution of Fe_3C in iron has a definite composition, which is 1.57 per cent. carbon—it is usually called metallurgically *saturated austenite* or *Ledeburite*. The fact that the compound Fe_3C is not stable at high temperatures, that is, temperatures above the melting point of malleable iron, is a source of great trouble in the malleable iron industry, as it is the first essential point to produce castings with no free carbon present after cooling.

In the case of iron and carbon, three agents produce this undesirable carbon: (1) Slow cooling; (2) prolonged heat above 1,000 deg. C. (these two points are very closely related); and (3) a large amount of carbon.

When these alloys containing all the carbon in the combined form are cold, they are too hard to machine and are exceedingly brittle, and the annealing treatment to which they are subjected makes the castings fit their name—*malleable*.

This treatment is simply one which alters the condition of the carbon. It has been previously stated that heat tends to break up the Fe_3C into carbon and iron (Fe_3C + heat = 3Fe + C.).

Now, whilst preventing this action from taking place in the melting practice, it is necessary for it to take place during the annealing operation. A temperature range between the extreme limits of 700 and 1,000 deg. C. is used for annealing and the breaking up of the Fe_3C takes place, but as the metal is so rigid at this range, the carbon cannot collect together to produce large, weak patches of graphite, so the ultimate result is a matrix of ductile ferrite dotted with small carbon nodules.

Hence the finished result is a metal with the following properties: (1) Almost as ductile as pure iron; (2) as strong as pure iron; (3) superior machining properties to pure iron; and (4) of the desired cast shape.

The above traces the origin of malleable iron, using pure iron and carbon. Commercially this is never the case, as other elements are present in the pigs used.

Influence of Silicon.

Silicon forms a silicide of iron (FeSi), which dissolves in the iron like Fe_3C. As FeSi dissolves, Fe_3C is thrown out and graphite is produced. The use of silicon as a softener in ordinary foundry practice is an illustration of this throwing out of carbon, producing a softer metal. Hence a lower annealing temperature or a shorter anneal is required with higher proportions of silicon, other elements being the same.

(To be continued.)

The Manufacture of Neutral Sulphate of Ammonia by Direct Absorption.

There is an ever-increasing demand in the agricultural world for neutral dry sulphate of ammonia, and this demand cannot fail to grow in proportion as the properties of neutral sulphate become more widely known.

Before describing the method of absorption it may be interesting to consider the advantages possessed by neutral, dry sulphate over acid, wet salt, which may be summarised as follows:—(1) Increase in content of ammonia from 25 to 25.5 per cent., giving an increased value of 6s. per ton; (2) absence of acid, increasing the value of the salt by 7s. per ton.

An acid-free salt can be readily dried, and the physical properties of dry salt, such as its freedom from lumps, further materially increase its selling value. There is also a considerable economy possible in bagging, since the dry salt does not rot the bags. The double twill bags necessary for the transport and storage of wet acid sulphate may be supplemented by single-hessian bags, which would cost less than a third of the price of the double bags, resulting in an economy of approximately 13s. per ton of salt.

On the question of economy in the manufacture of neutral sulphate, it is hardly necessary to add that evaporation of neutral liquor reduces the corrosion on the evaporators to a negligible quantity.

The process under notice was devised by the owners of a large Mond-gas-plant installation in Scotland, and the advantages we have enumerated are the results of their working experience over a period exceeding five years. The process is now being exploited by the Power Gas Corporation, Stockton-on-Tees.

The method employed is essentially a direct absorption process, the absorption of the ammonia from the gas being carried out in two separate compartments, the raw gas (from which no ammonia has been absorbed) is treated with liquor which is practically neutral, while the gas is finally stripped of its ammonia in the second compartment. In other words, the liquor of the first compartment is being neutralised by the gas, while in the second compartment the gas is being stripped of its ammonia by acid liquor. As carried out in a Mond plant, there has been proved to be no loss of ammonia in the absorption—the absorption efficiency of the apparatus being 99.17 per cent. in various tests extending over a period of five years.

The sulphate, as made in the evaporators, has an average ammonia content of 25.28 per cent. NH_3 and acid content of 0.0127 per cent. H_2SO_4. After drying, the ammonia content rises to 25.57 per cent. NH_3, and the acid content drops to 0.0113 per cent. H_2SO_4, figures which are averages of several hundreds of daily tests.

From the foregoing there would appear to be no doubt that this system is a satisfactory way of making neutral sulphate by direct recovery, such as is used on a by-product recovery gas-producer plant, but why should not something similar be introduced in the working of direct-recovery coke-oven or town-gas plants?

Contraction and Shrinkage during Casting.*

By Robert J. Anderson,
Metallurgist, U.S. Bureau of Mines.

Little information has been published relating to accurate measurements of the linear contraction of the non-ferrous casting alloys and the total contraction in volume of alloys on passing from the liquid to the solid state. In foundry practice, patterns are usually made on the basis of a general figure for linear contraction of a given class of alloys—for example, aluminium alloys, brasses or bronzes—irrespective of the alloy employed. For instance, in making light aluminium alloy castings a general figure of 0.156 in. per foot (1 in 77) is employed as the pattern allowance, although measurements by the Bureau of Mines show that in forty alloys the range was from about 0.95 to 1.80 per cent.

When a metal or alloy is cooled from the liquid state at any temperature to the solid state at any temperature—say, to room temperature—its diminution in volume is the algebraic sum of three separate contractions—namely, (1) in cooling from any temperature in the liquid state to the freezing point; (2) in passing from the liquid state at the freezing point to the solid state at the melting point; and (3) in cooling from the solid state at the melting point to any lower temperature. These three contractions in volume have been termed respectively, (1) the liquid shrinkage, (2) the solidification shrinkage, and (3) the solid shrinkage. Reliable data as to the contraction of the various metals on passing from the liquid state to the solid state are scant, but on the basis that practically every well-defined property of the elements is a function of their symbol weights, it may be deduced that the contraction in volume of the metals is a periodic function of their atomic weights.

Definition of Terms.

The liquid shrinkage may be considered to be the amount of contraction in volume of a metal or alloy in the liquid state on cooling from any temperature in the liquid state to the freezing point. The greater the temperature interval through which the metal cools—that is, the higher the initial temperature of the melt—the greater the liquid shrinkage. The liquid shrinkage of a metal or alloy, therefore, is not a definite numerical value, but it varies with the temperature interval of cooling. Thus the weight of metal that can be poured into a mould at a higher temperature is less than at a lower temperature.

The solidification shrinkage may be defined as the contraction in volume of a metal or alloy on passing from the liquid state at the freezing point to the solid state at the melting point. Where an alloy solidifies over a freezing range, the solidification shrinkage is the contraction in volume which occurs from the beginning to the end of freezing. The actual amount of the solidification shrinkage varies considerably for different metals and alloys, and it may be markedly affected by the presence of impurities. So far as is known, bismuth and silicon are the only metals that expand on solidification, but a number of alloys expand, and some show expansions on cooling from liquid to solid, although the total volume change is a decrease.

The solid shrinkage is the contraction in volume of a metal or alloy on cooling from the solid state at the melting point to any lower temperature—usually the ordinary temperature—and it may be determined over any solid temperature range by experimental measurements, or by calculation from the formula for expansivity. Ordinarily, in foundry practice, the solid shrinkage may be regarded as the contraction in volume on cooling from solid metal at the melting point to about room temperature. The thermal expansivity is the reciprocal of the solid linear contraction.

The linear contraction of a metal or alloy is the diminution of length that takes place in a casting on cooling in a mould. The terms linear contraction and patternmaker's shrinkage are synonymous. Turner states that the shrinkage may be defined as the difference between the length of a casting and that of the pattern from which it was produced—that is, it is the difference in volume between the fluid metal in the mould and the resultant casting at the ordinary temperature. Shrinkage in this sense, therefore, does not take into account the various stages of contraction, arrest or expansion which may occur in an alloy, but represents the final volume change. In experimental measurements, the linear contraction may be most readily determined by measuring the diminution in length of a bar cast from a pattern of definite length. It may be expressed in percentage diminution in length, in inch per foot, or in terms of the patternmaker's shrinkage scale.

Patternmaker's Shrinkage.

In pattern practice for light aluminium alloy castings, the usual allowance for the shrinkage is $\frac{5}{32}$ in. per foot (0.156 in., or 1.30 per cent.), and if a casting is to be 1 ft. long, then the pattern is made 1 ft. and $\frac{5}{32}$ in. in length. According to Keep (and his version of the matter is accepted also by Turner and others), the general understanding is that the shrinkage of a casting is the difference in length (or any other linear dimension) between the casting and the pattern from which it was made, or rather, between it and the mould in which it was cast. Thus, the general figure for the shrinkage of grey cast iron is $\frac{1}{8}$ in. per foot, and the patternmaker, in taking measurements for the different dimensions of a pattern, uses a "shrink rule," which is $\frac{1}{8}$ in. longer than the standard foot-rule which is used to measure the castings.

West, however, calls "shrinkage" the decrease in volume in the liquid state, which requires feeding in casting practice, and applies the term "contraction" to the decrease in volume which takes place after solidification. Also, according to McWilliam and Longmuir, "technically, 'shrinkage' refers to the gradual lessening in volume of the fluid metal as it approaches the solidification point at which 'shrinkage' ceases and contraction commences, the latter being understood to refer to the lessening in length or in volume of the solid metal." Hailstone states that "liquid contraction" is the local contraction which takes place in the heavy part of a casting when the outside skin of that casting has solidified. He states also that "solid contraction" is the natural contraction which metals undergo when passing from the hot to the cold condition; solid contraction is also known as shrinkage. The arbitrary terminology applied by West and others to contraction in the liquid and solid states seems to be based on nothing rational, and the writer prefers the terminology of Keep and Turner, which is technically correct.—"Chemical and Metallurgical Engineering" abstract.

[We consider this article to be of the utmost importance, as it deals with the basic principles underlying the experiments of Smalley, Ronceray, S. G. Smith, and others. It shows clearly that the only troubles to be associated with liquid contraction are those of a mechanical nature, and, with the object of "clearing the air," we suggest that troubles arising from entrained air, gases from the mould and evolved from the liquid iron should be carefully dealt with as separate propositions. Every defective casting due to porosity, shrink holes or blow holes should be definitely ascribed to its cause before being discussed in a general way, as confusion can only result therefrom. To give an example:—If any particular casting contains a defect, the cause of that trouble must be definitely established before constructing any theory for the production of sound castings. Obviously, liquid contraction can introduce many defects, which should be the first subject to be investigated, using standard conditions and varying the compositions of the metal, and placing defects arising from the mould, entrained air, or excess of gas in the metal itself beyond discussion. Once this question of inherent shrinkage trouble is universally understood by foundrymen, defects from other causes will be relatively easy of solution.—Ed.]

* Extracted from "Reports of Investigations," Serial 2410.

Institution of British Foundrymen.

EAST MIDLANDS BRANCH.

Annual Meeting.

The annual meeting of the East Midlands branch was held on March 24, at the Loughborough Technical College. Mr. W. T. Evans (Derby) was in the chair.

The statement of accounts having been submitted, the HONORARY SECRETARY (Mr. H. Bunting) reported the General Council had approved under due regulations the formation of a branch reference library out of surplus funds, and the meeting approved of the principle.

Votes of thanks were accorded Mr. Evans for his services during the past two years, and also to Mr. H. Bunting, the hon. secretary, to whose zeal much of the success of the branch, which is a difficult one to work, is due. Mr. Pemberton was thanked as auditor.

Mr. S. H. Russell (Leicester) was elected as the new President, Mr. Evans saying they would have a worthy man to carry on the high traditions of the office.

Mr. J. Lucas (Loughborough) was then elected Vice-President, in the place of Mr. Russell, and Messrs. H. Pemberton (Derby), E. Stevenson (Notts), and J. C. Cox (Ilkeston) were re-elected.

A ballot took place for three places on the Committee, and Messrs. S. Worcester (Leicester), C. W. Bigg (Derby), and Blackwell (Loughborough) were selected.

Messrs. H. Pemberton and T. Goodwin (Derby) were appointed auditors.

Mr. H. Bunting was re-elected as hon. secretary, and Mr. J. Lucas and Mr. T. A. Spiers were selected to act as representatives to the Central Council.

The SECRETARY reported the average attendance at meetings to be 35, which was rather lower than a year ago. With the exception of six, all the Peterborough members had dropped out, and the membership was now 93—27 full members, 58 Associate members, and 8 Associates. There were five additions during the year.

MR. RUSSELL then took the chair for the first time as President, and moved a vote of thanks to the authorities who had lent the branch rooms for meetings. Associated with this was the name of Mr. J. F. Driver.

MR. RUSSELL then called upon MR. W. T. EVANS to read his Valedictory Address.

Mr. W. T. Evans' Valedictory Address.

MR. W. T. EVANS then gave his Valedictory Address, remarking that the subject with which he intended to deal was a general survey of the foundry, together with a few remarks with reference to the Institute and also the East Midlands Branch. Some items in foundry practice will be touched on very lightly, not because of not being worthy of notice, but as all foundrymen are interested in some detail of the industry more than another, with such a vast field to cover, one can only pick out the most salient features that come within one's own small sphere of foundry activities.

There can be no doubt that much of the progress made in foundry processes and materials is the fruit of meetings and Papers read by members of the Institution, who have given of their best for the benefit of all who wish to place the foundry industry in the position it is justly entitled to, as the foundation of many metallurgical and engineering processes. It can be taken as an accepted fact that foundries have vastly improved during the last ten years in every way, but there are still many foundries which are not fit to be worked in; this may seem a drastic remark to make, but facts do not improve for hiding. There are badly-lighted, ill-ventilated, and sadly-neglected buildings in use as foundries, which are anything but pleasant situations for foundrymen in which to pass their working hours.

This class of foundry will not be able to face the competition of the well-equipped modern buildings which are now being erected, and the foundryman will no doubt obtain work at the most suitable shop in the interest of his own health and happiness, as a building with modern lighting, heating and ventilation is all in favour of good work and good health.

Foundry Plant.

There is now so much foundry plant to be obtained that much capital can be wasted by buying plant which is entirely unsuitable for the work to be produced. There are also many types of cupolas, but the chief improvement over the older types is the drop bottom, which saves very much hard work at the end of the cupola-man's by no means easy day's work.

There are cupolas over fifty years old which melt iron as efficiently as some of those with the latest improvements, the coke consumption, heat of metal, and speed of melting being all that could be expected from such a cheap method of melting. The worst feature of the cupola is that one cannot control the mixtures within fine limits as in open-hearth furnace practice, and with this point in view the results achieved are not to be belittled.

This seems to be a recognised fact in the U.S.A., as, from a Paper by Dr. Moldenke which appeared in THE FOUNDRY TRADE JOURNAL, he strongly advised engineers to buy their different grades of castings from foundries who specialise in the particular articles required, which means that a foundry making light castings would be able to run the same mixture the whole of the heat, and this would apply to other grades of castings. This would no doubt minimise the error in melting in the cupola.

As a rule, in malleable practice, one does not melt in the cupola irons other than those suitable for this purpose, owing to such a small limit in their Si. content, which spoils the annealing process.

In grey-iron foundry practice, the foundryman often tries to obtain irons varying from 1 to 3 per cent. Si. in the same heat, and this is a fruitful source of failure. Therefore, the American practice of specialising in classes of castings certainly helps to obtain a more uniform mixture.

Coke Consumption.

The consumption of coke per ton of metal melted will nearly always raise a heated discussion between foundrymen, and one well-known member of the Institution states in a Paper that every foundry which uses above 2 cwt. per ton of iron melted is unnecessarily extravagant. This would make it appear that there are more extravagant foundries than otherwise, and that the only way to get down to this figure is to obtain enough orders. Consumption of coke must vary in most foundries owing to the difference in the class of castings to be produced, and the average is no doubt above 3 cwt., based on castings produced, which is the only correct method of estimating melting charges.

Moulding Machines.

The types of moulding machines now in use are very varied, and most foundries have some kind of machine in operation. The fact of there being so many different makes of machine proves that foundrymen must have special machines for special jobs. For work in medium shallow boxes, the hand, hydraulic or air squeezer have all their uses; for the deeper class of boxes, the jolt will meet most requirements; for moulds with a deep draw, with large pieces of sand to be carried, the jolt ram turnover will be suitable; and for larger flat boxes, the sand-slinger seems to meet the situation.

With present machine-shop methods, and repetition work, machine moulding is a necessity, as this method will produce castings correct to size and weight, and suitable for jigging, with a reduction in time and greater output from machine shops; in fact, the so-called mass production would be impossible unless the foundry had adopted machine moulding.

The worst objection the foundryman has to the production of castings in large quantities is that very often the machine shop, owing to the expense of "setting up" a machine for certain castings, will not commence operation until there is a considerable number of the castings required, de-

livered. When the machining is commenced, there is perhaps a very small defect brought to light which could not be observed in the black casting, with the result that a large quantity of castings are scrapped, whereas, given a fair chance, the foundry could have overcome the trouble before the job had proceeded past the first few castings.

It is a common occurrence to hear foundry foremen say, "I do not want to proceed with that job until the first batch are finished machining." The machine shop should bear this in mind, and think that nothing pleases a foundryman more than to see numbers of castings going through as a good job, but a very few wasters soon give him the "hump." No machine shop foreman will go ahead until he knows that his jigs have passed inspection, and that the samples machined in the jigs are satisfactory; this applies more so to the foundry.

With the increase of machines in the foundries of so many different designs and moulding methods, the successful foundryman must have more mechanical training than formerly, as many of the machines are highly finished examples of intricate mechanism, and obviously, under foundry conditions, if neglected, they will not be efficient, and will soon find their way to the scrap heap or be branded as unserviceable.

It is common for machines to be out of service for considerable periods owing to no other reason than neglect in cleaning and oiling. The fact of working in sand should make everyone who has to do with moulding machinery do their utmost to keep them clean.

Under the best of foundry conditions and care, certain types of moulding machines will not have a long life, and should be depreciated at a fair figure, and this should be kept in view when estimating the cost of jobs produced; machine moulding is not all gain, and it is questionable if such gain is not mostly to the benefit of the machine shop.

The success of machine moulding very often depends on the pattern-shop, as, unless the patterns used leave the moulds properly, the moulder having to do a minimum of finishing, or in many cases no finishing, there cannot be real progress.

Materials.

The position with regard to materials for use in the foundries has now very much improved, and is almost normal.

There is a decided attempt by the blast furnaces to supply irons to analysis, and in the near future there will be further improvement.

Foundrymen cannot hope to obtain metal for use in the iron foundry as near to specified analysis as obtains in non-ferrous foundry practice, but experience shows there will never be the need for such fine working in grey-iron foundries.

Coke has improved, and a return of the troubles owing to coke of inferior physical condition and high sulphur content is not desirable, as coke cannot be too good, for it is a vital factor in successful melting, and the production of castings which must have a normal S-content. There is still room for further improvement in the quality of cupola coke.

Sands.

There is much improvement in the preparation of sand used in the foundries, and members would be well advised to read the book just published on "British and American Foundry Practice, with Special Reference to Refractory Sand," by H. Boswell. There may be more information in it for steel than iron foundry practice, but the book is full of information which will be of interest to the foundryman, whatever his particular branch of the industry may be.

Another feature is the remarkable way in which the use of "sea sand" or similar classes of sands has increased during the last few years, and it is safe to say that it would be impossible to produce many of the intricate castings now demanded without the use of artificially-bonded sands, and it is current practice to make cores with this material from ounces to tons in weight, and with success. The mixture of sand may be a little dearer, but there are less core-irons to be made, and the advantage in fettling castings alone amply pays for the increased cost; also there is very little wear and tear to patterns and core-boxes.

Runners and Risers.

There have been numerous discussions and papers on the pouring and feeding of castings, and it would appear that many foundrymen thought the methods shown would overcome most troubles arising from the methods in use generally, but even Mr. Ronceray does not suggest that casting with small runners under pressure will suit all jobs. In many castings, heads are *not* put on for feeding alone, but to overcome troubles found during machining, as in casting cylinders vertically there is always a tendency to get small blow holes in the barrels if no head is incorporated.

With castings of even sections in grey iron there may be no need for risers, but with uneven sections, unless "denseners" or chills are used, it is difficult to see how risers or feeding can be omitted.

In the discussion on a paper on this subject before the London Branch of the Institution, a member stated he had done away with feeders, etc., on malleable castings, and had adopted chills instead. This is no new departure, but chills will not overcome a "pipe" in a casting; only excess metal or feeding will do this.

In the U.S.A., where it is generally conceded that they are much ahead of us in malleable practice, chills have been replaced by sufficient feeders and risers, with an improvement in the output and quality of the castings. Feeding of malleable castings of uneven sections is not to be overcome by small runners without feeding. From experience in the production of castings from irons varying from the softest used to low Si grey iron, and also white irons, for malleable castings the lower Si which, as a rule, means a higher S-content, the greater the provision to be made for feeding.

The percentage of shop-scrap, risers, runners, etc., is very low in foundries using open mixtures, whereas malleable foundry shop-scrap will be somewhere about 50 per cent. more or less, according to the class of castings produced. This shows that the nearer the "steel white cast-iron series" of iron used is reached, the greater the quantity of iron to be melted to produce sound castings. The area of "gates" to pour castings should be increased as the Si content is reduced, as it is necessary to run the low-Si irons quicker, owing to the material solidifying much sooner. In fact, if a fairly large casting is run with a small gate made from, say, a 1 per cent. Si mixture, it will be solid before the mould is full, with the familiar result called a "short run."

Feeding Non-Ferrous Work.

It is common practice in non-ferrous work to make gun-metal castings (88-10-2) without risings, and there exists large quantities of castings which had to be perfectly tight under pressures from 2,000 to 3,000 lbs. per sq. in., successfully made without risers, but here provision was made for feeding by ample runners and gates, and also pressure.

On the other hand, these methods would not be successful if used in the production of the same castings in manganese bronze; this material requires small runners and large risers. This seems to prove that in all cases the lower the relative casting temperature, and therefore the quicker the solidification, the greater the provision to be made for feeding to obtain soundness.

It seems to be essential to run any casting sufficiently fast completely to fill the mould before solidification takes place. If this is not done in the case of an iron casting of a low Si content, there will be, in the thinner sections, chilled or undercooled places which will not be capable of being machined, whereas, if cast sufficiently quick to fill the mould with hot metal, there will be a better chance for the C to graphitise: and, as the whole of cast-iron foundry practice is based on the effective graphitisation, we are compelled to adopt methods which achieve this object.

Semi-Steel.

There seems to be too much ascribed to the use of steel in cupola-melted irons, and with some engineers it is becoming a fetish. There is an idea that, provided a foundryman can use scrap steel in his irons, that he will make a success of

any class of casting; this is far from the facts. The use of steel should be elementary knowledge to the efficient foundryman, and as simple as using pig or scrap.

It would appear that, if some enterprising party would supply steel in the form of broken pig-iron, the difficulty of using steel would be overcome; the fact of scrap steel being in the form of bolts, shearings, angles, tees, etc., does not add any other materials to the charge than pig-iron. Given a knowledge of mixing by analysis, and what is suitable for the sections of castings to be produced, to make the so-called semi-steel is ordinary cupola practice, and nothing else, and has been used by well-known foundrymen for many years.

It can be stated that, as to the improvement of irons by the addition of steel, is that it lowers the total carbon, therefore giving smaller flakes of graphite; it also lowers the phosphorus content, both of which features give a stronger and better material.

Most writers say that the total carbon content is higher, or at any rate not lower, but this is doubtful, as, with high total carbon in a grey iron, there would certainly be large areas of graphite. The lower total carbon seems to be an improvement in the strength of malleable and grey iron.

Technical and Scientific Books.

With reference to the provision of books and literature on foundry subjects, it is put forward that each branch should have a small library from which members could borrow books for stated periods; this may already apply in some branches. Some of the books are too expensive for a few of the junior members, and money for forming a collection of such books for reading and study would be of great assistance. This implies that in any collection of books made by a branch each book would no doubt be recommended by some member who had benefited by such book as he recommends.

Chemist in Foundry.

There has been some controversy lately as to the position of the chemist in the foundry. The first step to successful management is the control of materials used in all foundry processes. There are many foundries where this may not be absolutely essential, but they would be no worse for controlling their materials. The analysis and control of materials is only a means to an end, and cannot by itself produce good castings, but it is the foundation for obtaining the results hoped for. The chemist who has only the training as chemist can never be of service to the foundry other than to analyse materials.

On the other hand, a chemist who is also a metallurgist and capable of running the cupolas, and interpret foundry phenomena, etc., is a valuable asset to the foundryman, but unfortunately he is quite scarce at present. The foundry should give the laboratory each day a list of the charges to be melted and, given a competent chemist or metallurgist, the material asked for will be obtained as near as possible from cupola practice.

It is not fair to expect the laboratory to know just what class or quantity of iron is necessary for each day's cast. This can only be given by those in charge of the foundry, as, in the event of running three or four analyses of irons in the same heat, the foundry should state definitely what weight of each iron is needed, also at what part of the heat such iron will be used; this will give the chemist a chance to obtain good results.

The foundry must work strictly to the programme—a difficult matter sometimes, owing to the unexpected happening. The chemist should see all charges weighed out and placed in the cupola in their proper rotation; no foundry foreman or manager can successfully supervise the employment of iron when melted and at the same time control the charging of the cupola.

It is good practice to make the chemist responsible for the production of the material at the furnace spout, and, given amicable relationship with the shop, the question of the place for the chemist in the foundry will take no further solving.

The foundry should discuss with the laboratory the irons that are to be used for each job as it is received, so that proper arrangements can be made for pouring, etc.

Apprentice Problem.

The training of the apprentice foundryman seems to be one of the chief problems the Institute should endeavour to solve. This subject has been referred to in several of the Branch-Presidential addresses, but unfortunately a satisfactory solution is not in sight. The term "apprentice foundryman" is purposely used, because it is meant to include the pattern-maker and moulder, for, with modern practice in foundries, it is essential, in order to be efficient in the art of founding, to have knowledge of both departments.

From one point of view the pattern-shops are in almost the same position to the foundry as the jig and tool room are to the machine shops, that is, the pattern-maker has to supply the tools for the production of the casting in the foundry, and no foundry can be really efficient unless the patterns, etc., are constructed in a practical manner for this purpose.

With modern moulding-machine practice, a suitable pattern makes all the difference between success and failure; in fact, a poor pattern will make a job cost more for machining and moulding than otherwise.

Another feature which should be better understood by the pattern-shop is the provision of gates and runners for moulding-machine practice; if properly carried out, this will simplify the production for the moulder. There are numbers of pattern-makers in this country who have hardly seen the inside of a foundry and have a very hazy idea of the methods used in moulding the patterns they make.

Mr. Evans remarked that he had been connected with establishments where a pattern-maker was not allowed to go into any other department, which obviously was against making intelligent pattern-makers.

Again, there were a considerable number of master pattern-shops where the apprentice never sees any foundry operations. The only way of overcoming this difficulty, which can be stated to be pretty general, is to make it a condition of apprenticeship that the pattern-maker works inside the foundry and core-shops for some period, and this is the only method of making the pattern-shop efficient and in sympathy with the moulder.

If such a system were adopted, it is certain that much animosity would be eliminated between the moulder and pattern-maker, the two craftsmen necessary to progress in the industry. These remarks apply more or less to the apprentice moulder.

Some assert that if the pattern-maker is properly trained and can give the foundry the desired patterns, etc., to carry out the work, that there is no need for further discussion. One of the worst failings of many moulders is their inability to read a drawing or sketch. This is not because they have not the ability to achieve this, but lack of opportunity. With the pattern-maker this is part of his training, and he has to construct almost all his work from drawings or sketches.

If the moulder could explain to the pattern-maker, from the drawing, the methods he intended to adopt in the production of the articles under discussion, and the pattern-maker had the necessary foundry practice to apply them, it would be a gratifying improvement on present methods.

From these remarks it will be seen that the same education must be applied to the apprentice moulder as pattern-maker, *i.e.*, he must spend some time in the pattern-shop and become conversant with the practice there.

Some may raise objection to this by stating that there are more apprentice moulders than pattern-makers, and that there will not be accommodation in the pattern-shop for them.

All the youths employed in the foundries will not be sufficiently enthusiastic workmen to give their minds to intensive training, which implies that the foreman or management concerned will have to pick out the most suitable candidates and give them the opportunity to improve their status, or, in other words, help those who show signs of becoming efficient in the art.

One cannot fail to notice that some boys are always asking for better work, and endeavouring

to get on; also the rivalry that is caused by the boy working on what is considered the best job.

On the other hand, there is the boy who never takes the slightest notice of what job he does, and has very little interest in anything to do with the work he is employed on. The former boy can be improved by technical education, but to apply what Mr. Riddell calls "spoon-fed education" to the latter individual would be a waste of effort. One does not blame the lackadaisical boy personally, as everybody recognises that, more or less, heredity and environment are factors in life, and will no doubt continue for all time, no matter how one tries to overcome them.

Mr. Evans suggested the Institute should appoint a committee to draw up a scheme for apprentice foundrymen, which would not differentiate between moulders or pattern-makers.

These remarks have dealt with the practical side of the business. There would have to be classes, preferably in the daytime, for teaching other necessary subjects, which would apply to those who showed their ability as craftsmen. There can be no scheme to educate all to be at the top, as all would then be at the bottom, and progress stationary; pioneers will always exist.

Status of the Foundry.

The production of castings is becoming more difficult every day, owing to the more intricate design. Specifications are more drastic, and, in fact, no casting can be too good for the engineer, but a very small defect causes rejection.

This shows that, unless the foundryman has an efficient training in his art to enable him to carry the job through from the drawing to the finished casting, not necessarily working at each process, but able to control such processes, he will have endless troubles, which might be avoided if tackled in time. The days of any individual interfering in the foundry, who has not some knowledge of the job, are past. The idea that foundries are anyone's job has been dispersed by the Institution, by education, and foundrymen are obtaining their position as being essential to the engineering industry. By this is meant the foundry has become in many cases a specialist job, and, from the general trend of events, will remain so.

There are many well-known scientific members in the Institution, many of them pioneers in their own particular branch of the industry, and no foundryman can do other than improve his status by becoming an active member. As members of the East Midlands Branch are aware, the Branch is a very difficult branch to conduct, and their secretary, Mr. Bunting, has a difficult task—for instance, in the obtaining of Papers

A feature of modern Papers is that they are too scientific to be grasped by just having them read through once, and it would be of great service if advance copies were available. This would help the lecturer and those who are interested, especially if questions were submitted beforehand. Perhaps this will be achieved in the near future.

Mr. Evans concluded by thanking the Branch officers and members for the support they had accorded him during his presidency, and hoped that Mr. Russell, the newly-elected President, would receive similar support.

Test Bars.

Mr. Evans then introduced a discussion on Test Bars, and read the general specification which is being put forward by the special Committee of which he is a member. They were, he said, most anxious to get a good consideration of the proposals, which were as yet only tentative. It was essential that every member should give his views, so that all criticisms and complaints could be considered before the Institution finally approved of the specification.

Mr. Evans then gave his reasons for the suggestion why there should be three sizes of test bars which must bear some relation to the size of the casting.

Slides were shown of micro-photographs of various bars, showing the structure of the metal, Mr. Evans fully explaining in each case.

After an interesting discussion, in which Mr. Russell, Mr. Greenwood, Mr. Lucas, and Mr. Driver took a prominent part, Mr. Evans said all the criticisms put forward should receive due consideration. He hoped also that, if any further points occurred, members would let him have them in writing. The whole basis of the Committee's recommendations was to bring the test bars in relation to the castings. It was not merely analysis of the castings, but the structure, which counted.

The British Cast-Iron Research Association.

Progress of Researches in Hand.

Standard Test Bar Specification.—The Committee have decided upon a basis for drawing up a National Specification. Agreed points have been arrived at, and it is expected that a preliminary report will be issued at an early date.

Internal-Combustion Engine Castings Research.—This work is being pushed forward. Castings, defective in design and manufacture, are being examined, and the investigation is being carried out, both on the engineering and metallurgical side. A draft specification for air-cooled and jacketted cylinders for automobiles has been considered and approved.

Shrinkage Defects Research.—This research, as it progresses, has broadened out to include the whole of the fundamental properties of cast iron, such as liquid shrinkage, solid contraction, physical properties, corrosion, etc. The preliminary report will shortly be issued to members, and will contain very valuable data.

Bulletin No. 2.—This will be of interest to members, as besides giving the results of the minor investigations carried out, it includes memoranda upon moulding sands, refractories, and shrinkage defects.

Standard Specifications.—The Association have under consideration specifications for cast iron for piston-ring pots, and also for concentric piston rings, which have been prepared in co-operation with the B.E.S.A.

Problems sent in by Members.

The assistance of the Director in investigating the difficulties of members has during the past month been of very great value, not only to the firms but to the Association. Valuable practical information has been obtained and collated for future researches. The problems sent in include defects in malleable casting methods; mixtures for cylinder castings; annealing malleable cast iron; defective engine-bed plates; brittleness in malleable castings; annealing grey cast iron; mixture for 6-in. bore cylinders; defects in 84-in. L.P. cylinder liners; effect of high-silicon hematite irons on castings; chilled iron rolls.

The Bureau and Library.

The Library Committee have, by the splendid gift of the Birmingham Chamber of Commerce, been able to purchase over 100 books. The Library now possesses a complete range of all the works upon foundry practice, and will be a very valuable asset to the members and associates. The catalogue will be issued at once, and it is hoped members will make full use of the Library.

Thirty-nine books have also been presented during the month by various donors. The proceedings of all the technical societies, both of this country and America, are now in the Library.

Inquiries for information have been sent to the Bureau by members upon physical properties of clay; cupola calcining of dolomite; core-making machines; oil-fired furnaces; painting of cupolas.

Membership.

During the past month the membership has very materially increased, and, without doubt, ironfounders are wakening up to the vital necessity of joining the Association.

Propaganda meetings are being held in various parts of the country, and the secretary will be pleased to attend any meeting of ironfounders to discuss the work of the Association.

Research in America.

The Production Department of the United States Chamber of Commerce report that American industries are spending 70 million dollars annually on scientific research. As a result of this work it is estimated that one-half billion dollars are being saved annually by American industry.

An Apprenticeship Course in Foundry Practice.—XXXIX.

By Ben Shaw and James Edgar.

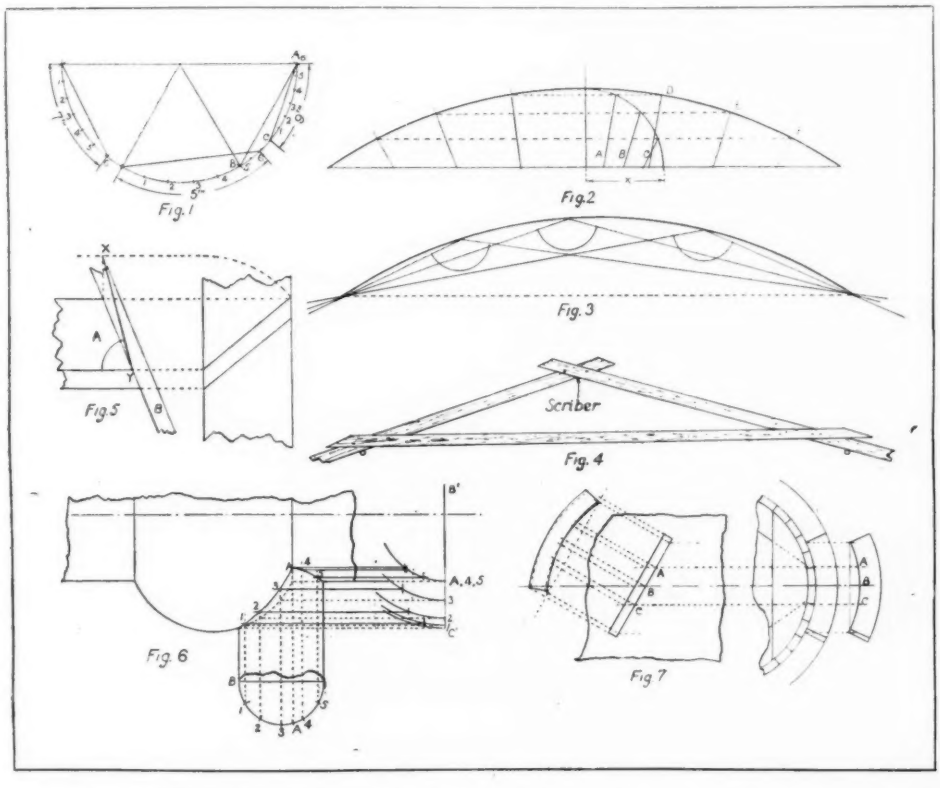
THE VALUE OF GEOMETRY.

Geometry treats of the measurement of lines, angles, surfaces and solids, and with their relations to one another. It forms the basis of representing the formation of any piece of mechanism, and thus provides an avenue by which the designer can convey his ideas to those capable of converting them from the abstract to the concrete. To those that have nothing more definite than a machine drawing to work from, a knowledge of geometry is essential. A knowledge of machine construction is an acquisition and very desirable, but the primary requirement is a knowledge of geometry. In the foundry trades it is the pattern-maker that should have more than an elementary grasp of the fundamental principles of geometry, and who should be capable of applying them as the necessity arises. It is the pattern-maker who visualises the required shape of the casting, and he can only do so by examining the various geometrical projections in their correct relation to one another. In this process he demonstrates his capacity for "reading" a drawing. Although the ability for reading a drawing makes for efficiency and skill, as a craftsman, he must be able to apply the principles of geometry in order to define or develop shapes that are not definitely portrayed on the drawing, only represented by dimensions, or that are necessary in the construction of a suitable pattern.

It is not possible to deal comprehensively with the principles of geometry in an article of this character—students are referred to one of the many text-books on this subject—but we purpose dealing with some of the practical applications of geometry not only as an aid to the pattern-maker, but also to the moulder.

Chords.

One of the common requirements is that of dividing the circumference of a circle into a given number of equal parts. This is frequently necessary in locating ribs, bosses, etc., on a wide variety of work or for setting teeth on a wheel. The usual practice is to set the trammels or dividers to an approximate size and test until by repeated trials the desired chord is found. Much time is frequently occupied in this method of dividing by trial, and the correct positions are often mutilated and difficult to locate on the same circumference after many trials. When it is necessary to set off lines from a given centre represented by a certain number of degrees, or to divide a circle or circumference into a definite number of equal parts, the chord may be calculated from the number of degrees and the diameter of a circle capable of being described on the job. This ensures accuracy and frequently saves time. To obtain the length of chord, refer to the natural sine for the number of degrees given, and multiply half this by the number of inches in the diameter. A table of natural sines will be found in any engineers' pocket-book. A short table of chords dividing the circumference of a circle into 3 to 17 parts may be found useful in setting out segments, ribs, wheel arms, etc. This can, of course, be extended by reference to a table of natural sines.



No.	$\frac{S}{2}$	No.	$\frac{S}{2}$
3	0.86603	10	0.30902
4	0.70711	11	0.28173
5	0.58779	12	0.25882
6	0.5000	13	0.23932
7	0.43388	14	0.22252
8	0.38268	15	0.20791
9	0.34202	16	0.19509
		17	0.18375

The quantities under N represent the number of equal parts desired, and those under S repre-

sent the sines of half the angles. Thus, if a circle 5 ft. dia. is required to be divided into 10 equal parts, multiply 0.30902 by 60, which equals 18.5412 inches as the length of the chord, or, represented in practice, it would be just bare of 18 35-64 in.

Another method, which does not introduce calculations and yet localises the amount of the circle over which division by trial is required, is shown in Fig. 1. In this instance the length of an arc marked off by a chord equal to its radius is divided into a similar number of equal parts, into which the whole circle is required to be divided, and six of these parts will give the length of chord required. Thus, in Fig. 1 the chord AB represents a division of $\frac{1}{8}$, and, if the arc contained in the segment it forms can be divided into 9 equal parts, the length of chord over 6 of these parts, as at AC, will divide the circle into 9 equal parts.

Drawing Arcs without Trammels.

The radius of a required piece of work is sometimes so great that the floor space available is not sufficient to set out the work, or it may be difficult to procure a beam for trammels so that they could be set to the required length and be sufficiently rigid for the purpose of describing the arc. In such cases it is necessary to draw the arc without a centre. A chord should be drawn to enclose the length of arc required, and from its centre should be marked off the height of the arc. This can be calculated by subtracting the square of one-half the chord from the square of the radius. Extract the square root of the remainder, subtract it from the radius, and this will give the height of the arc. With the height of the arc and the extreme ends of this chord three points are given through which the required arc will pass. Either of two methods may be used, and both involve geometry. A number of points may be developed through which the arc will pass, in the manner shown in Fig. 2. To do this, the chord is set out on a drawing-board, and on a vertical line from its centre the height of the arc is indicated. From the centre of the chord, and with a radius equal to the height of the arc, describe a quadrant. The arc of the quadrant should be divided into a convenient number of equal parts, and that part of the chord represented by the quadrant, marked X, into a similar number of equal parts. Join the points in the manner shown with lines A, B and C. Now divide half the chord into an equal number of parts, as has been used with the quadrant, and from each point draw lines D, E and F parallel to A, B and C respectively. From the points at which A, B and C intersect the quadrant draw lines parallel to the chord, until they cut the lines D, E and F. The intersections of these lines give the points through which the arc will pass, and a thin lathe of parallel thickness may be bent so that a line may be drawn to represent the arc.

While it is as well to be familiar with the foregoing method, a more practical method is available. This consists of making use of the geometrical principle, which establishes that the angles in the same segment are equal. Thus, if the height of the arc be determined and lines are drawn to the ends of the chord, an angle is formed which represents the angle of the segment. By varying the position of this angle, but with the lines always passing through the ends of the chord, points may be marked through which the arc can be drawn, as in Fig. 3. This is applied practically by making a frame enclosing the required angle, as shown in Fig. 4, and introducing nails or screws at the ends of the chord against which the frame can ride. If the frame is moved so that the full distance of the arc is travelled, and a scriber is used at the extreme point of the angle, the required arc will be drawn.

Determining Bevels for Angled Work.

Much time and also timber is wasted through the inability to mark off bevels accurately. When only one end of a piece of material is to be bevelled, it is probably just as profitable to make a fit by trial, but when both ends are to be bevelled, a fit by trial may very easily involve another piece of material. It is often better to mark off the bevels, and if this is done accurately, the subsequent fit will be all that could be desired. A simple illustration showing a method for determining the necessary angle is seen in Fig. 5. In this instance, A may be taken as a rib butting against a plate B; it is required to mark off the end of A, so that, when cut, it will fit accurately against B. Both front and end elevation are necessary. If the width of rib A be marked in a vertical direction on the end elevation and projected to the front elevation, and a vertical line be drawn from the back of the rib at the point of contact with the plate to intersect it, then the line XY will form the angle to the horizontal at which the rib A should be cut. The other angles required are obtained direct from the drawing. The same principle can be profitably used in determining bevels for more complicated work.

Developing Points for Filling Parts.

The method of obtaining some definite guide to the junction shapes, represented by the intersection of solids of varying forms, is very necessary to the pattern-maker. Even though templates and jigs may be used to assist in cutting a fitting shape, or hermaphrodites may be used to mark off a line on the part to be fitted which coincides with the part against which it is to be fitted, the ability to mark off the required shape geometrically is an advantage. It may be the only skilful method possible, or its use may cut out the cost of an elaborate jig. A pattern-maker, who is unable to project and obtain suitable points for the ordinary fitting shapes is lacking in skill. Some pattern-makers persist in fitting by trial, and hours are spent on work that could well be done in a quarter of the time if definite points of contact are first developed. A simple example is illustrated in Fig. 6, which represents a circular branch fitting against a circular-shaped body. The energy and time involved in cutting the branch to the requisite shape is considerably reduced by marking the shape of the contact, because the bandsaw can be used effectively and with more confidence. The shape is obtained by determining the intersection at a number of convenient points and using a "doctor" to give the line passing through them. The development should be set on a drawing-board and then transferred to corresponding positions on the branch. It is convenient to divide a semi-circle, representing the diameter of the branch, into a number of equi-distant points, 1, 2, 3, 4 and 5, and at any definite point the plane through which passes a desirable point on the intersection, as at A. Longitudinal lines are next drawn parallel to the branch. From the point of intersection between these lines and the main body other lines are drawn, but parallel to the centre line of the main body. Arcs representing the shape of the main body at these different points can then be drawn, and the respective heights of 1, 2, 3, A, 4 and 5 from B C marked off on the corresponding arcs, as shown in sketch, and horizontal lines projecting from the intersection of these heights with the arcs to the projected lines from the branch. Thus, the corresponding points 1, 2, 3, A, 4 and 5 are determined at the end of the branch to be shaped through which a line can be drawn.

Value of Projection.

Another illustration of the value of projection is shown in Fig. 7. Again a simple example has been chosen, so that the apprentice may grasp the principle and apply it to more difficult work. In this case a flange is required about a large cylindrical body at an angle to its axis or longitudinal centre. In such instances it is frequently necessary to prepare the work in detail, so that many men and apprentices may be employed. Some parts can be more readily prepared when the main body has been made, but, as a rule, details can be made direct from the drawing-board, and this applies to the angled flange referred to. There is really no difficulty in preparing the flange in segments, without any fitting by trial, if a few points are obtainable in the manner shown. A part end elevation will give the length of segment desirable at right-angles to the axis, and its chord is divided into three or four parts; from which lines are projected to intersect the front elevation of the flange in its required position on the cylinder. If lines are drawn from these intersections and at right-angles to the flange, any line may be drawn at the same angle as the flange, from which heights can be marked off corresponding to the height of the segment. Thus, the heights of the arc at A, B and C are marked off to represent the heights of both sides of the flange segment at A,

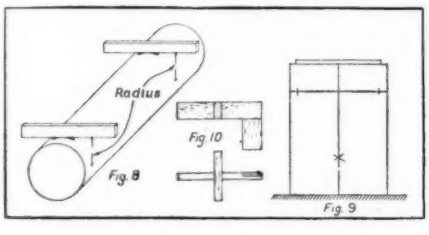
XUM

B and C, and either a "doctor" used to connect the points or a radius may be determined for describing the arc with trammels, the latter being preferable, as the remaining segments can be marked off without lifting the heights.

Geometry in the Foundry.

Apart from the method of dividing a circle into a definite number of equal parts, illustrated in Fig. 1, the foregoing has special reference to the application of geometry for the pattern-maker. Geometry has nevertheless considerable value in the foundry, and the fact that the moulder does not make as much use of it as he might does not reduce that value. Not infrequently, when setting out a job in the foundry involving elementary geometrical principles, the moulder depends upon the pattern-maker for the primary work. This should not be necessary. The loam moulder particularly should be conversant with geometry, because the limited patternwork supplied gives but little guide to the shape of the job, and he must visualise his requirements. He is responsible for the setting out of the tackle that may be necessary in the formation of a mould such as plates, rings, grids, etc., and these must be marked out on the open sand bed. It is necessary to be able to set out right-angles either by use of a wood square from a straight-edge or with the trammels, and when the lines to be drawn at right-angles to each other are long, it might be more convenient and more accurate to make use of the equivalent of 3, 4 and 5 as the base, height and hypothenuse of a right-angled triangle. Circles may be required to be divided for locating the centres of lugs or holes necessary in plates.

Although accuracy is not usually associated with the making of tackle, it is important that ribs and bosses should be set accurately, when they are



necessary in the making of a mould that is being swept. It is in this class of work that the method shown in Fig. 1 is specially useful, because it localises the length over which a trial division is made. The method of dividing by trial round a large job is very unsatisfactory, especially when the work is green, and the setting out must necessarily be done when the loam is in this condition if the subsidiary pattern sections are to be bedded in.

When loam patterns are made from which green or dry sand moulds are to be made, some preparatory setting out is usually necessary. Thus, with a swept pattern that is to be moulded horizontally, a centre line should be marked on to guide the sand moulder in making his joint. The method of obtaining points at each end of the cylindrical bodies is shown in Fig. 8. Parallel straight-edges are located until they are out of winding with each other, and half the diameter at the place on which each rests is measured at right-angles from the edge in contact. The springing of a chalked line, held taut between the points, will give the straight line desired.

With swept patterns that are to be moulded vertically, centre lines are generally necessary for locating subsidiary pattern sections. For this purpose a vertical line should be drawn from which the other centre lines can be marked. Usually some definite continuous line is formed about the cylinder during the time of sweeping, and this can be used as a basis for erecting the vertical line, as shown in Fig. 9. When a continuous line is not readily discernible, then some rough form of gauge, as in Fig. 10, may be used to make a definite line, or, if the pattern has been swept on a level bearance, any convenient piece of wood may be used to guide the striking of a line near the base of the pattern. When the first vertical line has been drawn, the remaining centres can be marked off in the manner previously referred to. It is more convenient to divide the periphery of a large job into eight parts and to use alternative points for drawing the centre lines.

Although the examples herein described are simple, it is surprising the number of journeymen, as well as apprentices, that find a difficulty in applying them. In both patternshop and foundry the ability to make use of geometry is a valuable asset, and confidence in its use is the outcome of practice.

Book Reviews.

Electric Cranes and Hauling Machines. By F. E. Chilton. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 2s. 6d. net.

This book is one of Pitman's Technical Primers, a series of books already well known to foundrymen, as the department has been well catered for in several volumes. This particular one possesses much of interest for the foundry manager, as he has more than an ordinary engineering interest in an overhead crane he thinks to employ. A satisfactory crane, from a machine-shop point of view, may be condemned by foundrymen on account of its proclivity to "snatch." The snatching of either a sand mould or a ladle of metal is always most undesirable, and sometimes dangerous, so much so that it has been, in some cases, thought wise to discard a three-phase supply in favour of direct current, though the difficulty can be invariably overcome by a power regulation. It is on account of such important matters as these that we would recommend this book for their consideration. Another section of interest is electric haulage, which with some layouts is an economical system of manœuvring wagons in and out of annealing ovens, core ovens and mould-drying stoves.

The book is divided into nine chapters, all of which, except the last, contain matter of interest for foundrymen. If their interest is awakened, there is a bibliography of the subject appended, from which further progress can be made.

Industrial Electric Heating. By J. W. Beauchamp. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 2s. 6d. net.

This is another of Pitman's Technical Primers. As a book for apprentices, it may serve to awaken their interest, but for anybody *au fait* with any of the numerous phases of the subject it leads nowhere. In this age of specialisation no person is interested, except in a popular sort of way, in both sealing wax heaters and brass melting furnaces. Startling headings, such as "Electric Steel from Tin Cans," would be interesting if it were shown to be commercially possible. Undoubtedly this can be done, *but* at such an expenditure of current as commercially to condemn it. We would suggest that in future editions many of the half-tone illustrations might usefully be replaced by line drawings, as in their present form, even in conjunction with the text, they give little or no information. Fig. 13, for instance, illustrates a Greaves-Etchell steel melting furnace of 1 ton capacity. It is one of the earliest models ever designed, and we have failed to find any reference to it in steel making, except the statement quoted as to the utilisation of tin cans.

Catalogues Received.

Liquid Starters. An illustrated brochure is to hand from the Brush Electrical Engineering Company, Limited, of 88, Kingsway, W.C.2. These are applicable for foundry overhead cranes and other machines where motors have to start against the load.

A Criticism of the Physics of Cast Iron.

Mr. J. E. Hurst points out that on page 262, column 1, paragraph 5 should read "These curves as they stand therefore afford *no* conclusive evidence."

Heat Treatment of Steel Castings.*

Unfortunately, the physical tests obtained from a casting, regardless of the number of test coupons or the manner in which they are placed, do not represent the strength of the casting as a structural unit. At points where changes of section occur in the casting—corners and other irregularities—serious internal strains are likely to be developed during solidification, resulting too frequently in interior checks, which are not apparent by surface inspection. The metal is also apt to be porous and spongy in localities where proper feeding has not occurred. Indeed, many castings are so designed that it is impossible for foundrymen to produce them without the presence of such interior defects.

A simple annealing treatment, when applied to plain carbon steel castings, has in general very little effect on the elastic limit and tensile strength, but does produce a decided increase in ductility, which results in a much greater resistance to impact stresses. Many castings of thin section will, in reality, have their elastic limit and tensile strength actually reduced by the annealing operation. Furthermore, a simple annealing operation tends to produce a uniform elastic limit and tensile strength throughout the entire section of the casting, and brings it more nearly to the condition assumed by the designer in his calculations. Furthermore, as the thickness of section does not have such a decided influence during a slow cooling operation, the test specimens taken to represent any given casting will more nearly represent the properties of the material in the casting itself than would be the case if the tests were taken in the unannealed condition or after a more rapid cooling operation.

There are many castings in which the question of wear is very important while the question of structural strength is not of as great importance. Undoubtedly the wearing properties can be materially increased by a suitable heat-treatment operation, and the Watertown Arsenal has successfully produced many thousand track shoes and grousers which have been subjected to a quenching and tempering operation. These castings are of relatively thin section, approximately $\frac{1}{4}$ in., and experience indicates that their life is materially increased by suitable heat treatment. It is not believed that a study of the ordinary tensile properties is sufficient to determine the effect of various heat treatments upon cast steel of different compositions, and it is believed that the results of the impact test are of considerable assistance in predicting the service behaviour for a given casting after different heat treatments.

A number of experiments has been carried out in the metallurgical laboratories at Watertown Arsenal in connection with foundry operations at this plant, and it is thought that a brief presentation of some of the results will be of interest. The chief application of the dynamic type of physical test has generally been to forged steels and other material, and although the methods of impact testing are now generally understood, it is thought that a brief description of the method and type of machine employed in these experiments may be of interest.

The machine used in the following tests is a Charpy pendulum machine, in which the blow or impact is delivered by a hammer swung as a pendulum. The pendulum is raised to a known angle and allowed to fall, acquiring an amount of energy in its downward swing under the action of gravity which is at a maximum at the moment when the centre of gravity of the pendulum is at the lower vertical, at which moment the force of gravity is perpendicular to the direction of motion of the hammer, and at this same moment impact with the test specimen takes place. The energy in the hammer at the moment of impact is readily calculated, knowing the weight of the pendulum, the distance of its centre of gravity from the axis of suspension, and the height of fall. After impact and rupture of the test specimen, the hammer continues to swing. Neglecting friction and air resistance (corrections for which are made in actual testing) the pendulum would swing to the same angle on the one side of the vertical as the angle from which it started on the other side of the vertical, if no test specimen were present.

Impact and rupture of the test specimen absorb a certain amount of the kinetic energy of the pendulum when it is at its lowest vertical position, and hence in its continued swing it will have only the excess energy after deducting the energy absorbed in rupture of the specimen from the maximum energy. This excess energy is easily deduced by noting the angle to which the pendulum swings after impact, and thus the energy absorbed at impact is obtainable.

In the tests, the results of which are given later, the Charpy machine had a hammer weighing about 50 lbs. and delivering a blow of about 217 ft. lbs. of energy.

The test specimens are small rectangular notched bars of the dimensions. The specimen, when placed in the machine, rests on two supports as a beam, and is struck by the hammer at a point directly opposite the notch.

The notch is made in order to prevent deformation of the material and concentrate stress at a certain point, so that actual rupture without deformation may be obtained.

The material used in the tests was steel made in a 6-ton basic-lined Heroult electric furnace. Samples were taken from production heats, and four impact test specimens and one tensile test specimen were cut from each. The heat treatments were carried out in the metallurgical laboratory, heating being done in Hoskins electric furnaces controlled by base-metal pyrometers recording on Leeds and Northrup recorders. The slugs were heat treated before the test specimens were machined.

The analysis of the two heats tested was as follows:—

No.	C.	Mn.	P.	S.	Si.
B5976	0.11	0.36	0.015	0.020	0.180
C6903	0.49	0.60	0.014	0.014	0.305

The tensile properties and the impact test results are shown in Tables 1 and 2.

The first treatment was a simple anneal at 825 deg. C. for two hours. The physical properties of the low-carbon heat were practically unaffected by this low temperature anneal, whereas the elongation and contraction of the high-carbon heat were very materially increased, the yield point and ultimate strength, however, remaining practically the same. The resistance to impact on the high-carbon heat was increased by this simple anneal at 825 deg. C. approximately four times the value obtained in the cast condition.

TABLE 1.—*Data and Results on Low Carbon Basic Electric Cast Steel.*

Treatments.				Physical Properties.					
Casting	Temp. deg. C.	Time	Quench	No.	Y.P. tons per sq. in.	M.S. tons per sq. in.	E. per cent.	R. A. per cent.	Charpy ft. lb.
B5976	As Cast			13	8.9	19.2	26.0	34.8	7.67
B5976	825	2 hr.	F.C.	12	7.8	19.4	25.0	40.3	8.12
B5976	925	2 hr.	F.C.	2	12.2	20.5	34.5	54.6	55.58
B5976	825	4 hr.	F.C.	3	8.9	20.3	31.0	67.0	40.20
B5976	925	4 hr.	F.C.	4	14.1	20.5	36.5	54.6	45.39
B5976	925	2 hr.	Air	5	13.4	21.0	36.0	54.6	57.74
	500	2 hr.	F.C.						
B5976	925	2 hr.	Water	6	13.0	21.4	41.5	71.4	68.32
	675	2 hr.	F.C.						
B5976	925	2 hr.	Water	7	14.5	23.9	35.0	64.7	64.98
	600	2 hr.	F.C.						

TABLE 2.—*Data and Results on High Carbon Basic Electric Cast Steel.*

Treatments				Physical Properties.					
Casting	Temp. deg. C.	Time	Quench	No.	Y.P. tons per sq. in.	M.S. tons per sq. in.	E. per cent.	R. A. per cent.	Charpy ft. lb.
C6903	As Cast			13	20.3	35.7	7.5	5.8	2.74
C6903	825	2 hr.	F.C.	12	20.5	36.1	15.5	20.0	10.85
C6903	925	2 hr.	F.C.	2	19.4	35.5	15.0	20.5	10.91
C6903	825	4 hr.	F.C.	3	19.8	36.1	15.0	20.5	10.39
C6903	925	4 hr.	F.C.	4	19.8	35.2	14.0	17.0	11.61
C6903	925	2 hr.	Air	5	21.9	37.9	17.0	20.5	13.42
	500	2 hr.	F.C.						
C6903	925	2 hr.	Water	6	22.3	36.8	21.0	34.8	16.92
	675	2 hr.	F.C.						
C6903	925	2 hr.	Water	7	25.2	42.6	15.0	30.5	14.61
	600	2 hr.	F.C.						

* Abstracted from an article published in "The Iron Age," by F. C. Langenberg (Watertown Arsenal, Watertown, Mass.)

The next treatment was a simple anneal at a higher temperature, namely, 925 deg. C. This anneal at a higher temperature increased the impact value on the low-carbon steel over 700 per cent., but on the higher carbon heat did not improve the impact values over those obtained on the lower temperature anneal. It will also be noted that the higher anneal on the high-carbon heat reduced slightly the elastic limit and tensile strength.

The next operation was to repeat the two anneals, increasing the period of soaking from two to four hours. The results obtained upon the higher carbon heat were very little affected by this increased period of time at the annealing temperature, whereas on the low-carbon heat the longer period at 825 deg. C. did result in a decided increase in the impact properties over those obtained by an anneal for two hours at the same temperature. The explanation of this, however, is quite simple. During the two-hour anneal at 825 deg. C. the material did not pass through the critical range, whereas during the four-hour anneal at 825 deg. the material had passed through the range at some stage during the soaking period.

The next treatment applied to both heats was an air chill from 925 deg. C. followed by a draw at 500 deg. C. The results on the high-carbon heat are of particular interest. The yield point and ultimate strength have been increased, as have also the results of the impact test.

The next two treatments applied consisted of water quenching from 925 deg. C., followed by a drawing operation at 675 deg. C. and 600 deg. C. respectively. Referring first to the tests resulting from the coupons drawn at 675 deg. C., it is to be observed that associated with the increase of yield point and ultimate strength is quite a material increase in the results of the impact test. On the material drawn at 600 deg. C. the yield point and ultimate strength are higher than obtained from the draw at 675 deg., which is, of course, as would be expected. It should be further noted that the impact values, although exceptionally good, are not as high as those obtained when the draw was carried out at the higher temperature.

Before leaving the discussion of these results, it is again desired to point out some of the dangers resulting from a direct application of results such as presented in the accompanying tables. Assume that heat C6903 was made to meet the following requirements:—Yield point, 16.7 tons per sq. in.; tensile strength, 35.7 tons per sq. in.; elongation, 14 per cent.; and reduction of area, 20 per cent.

With slight tolerances, any of the tensile tests reported would meet the specification enumerated above. If in the design of some casting the question of weight is becoming very troublesome, the designer, upon an examination of the table, might conclude that he could write a specification calling for:—Elastic limit, 22.3 tons per sq. in.; tensile strength, 37.9 tons per sq. in.; elongation, 14 per cent.; and reduction of area, 25 per cent., basing his deductions upon the results obtained by quenching the material from 925 deg. C. in water and subsequently drawing at 600 deg. C. If the casting was of simple section and comparatively uniform throughout, his expectations might be fully realised in practice, but the attempt to apply such a specification to any general line of miscellaneous castings would lead to very dangerous consequences, and ultimately result in many disappointing failures.

A similar set of experiments, although less detailed, were conducted on an acid open-hearth heat of the following composition:—C, 0.30; Mn, 0.62; Si, 0.18; S, 0.038; and P, 0.038 per cent.

The three treatments applied were as follows:—

Treatment A.—Heated to 900 deg. C., soaked two hours at this temperature and water quenched, followed by drawing two hours at 650 deg. C., and furnace cooled.

Treatment B.—Heated to 900 deg. C., soaked two hours at this temperature, and furnace cooled.

Treatment C.—Heated to 950 deg. C., soaked two hours at this temperature, and cooled in air, followed by drawing two hours at 500 deg. C., and furnace cooled.

The results of these tests are shown in Table 3. From an inspection of the mean results of the tests it is evident that water quenching has raised the elastic limit approximately 4.5 lbs. per sq. in. and the tensile strength 3.5 lbs. per sq. in. over that obtained by a simple furnace anneal. Furthermore, this has been accomplished with but little sacrifice of ductility. The shock strength, as measured by the Charpy impact resistance, has been increased from 11.32 to 14.25 ft.-lbs.

The air-chilled specimens show an increase in both elastic limit and tensile strength of approximately 3,000 lbs. per sq. in. over that obtained by a simple furnace anneal. This increase is in good agreement with that observed in the foundry annealing practice at this Arsenal in the production of what would correspond to the medium of hard grades of steel castings as specified by the A.S.T.M.

TABLE 3.—*Physical Properties of Cast Steel of Different Heat Treatments (Acid Open-Hearth)*

Yield Point, tons per sq. in.	Tensile Strength, tons per sq. in.	Elongation, per cent.	Reduction of Area, per cent.	Charpy Impact Test, ft. lb.	Brinell Hardness
25.6	38.8	15.3	22.8	14.25	176
21.1	35.3	18.3	27.2	11.32	156
22.4	36.8	16.2	23.9	11.87	159

Conclusions.

In conclusion, the author emphasises that:—

First.—Although experiments prove that physical properties, including resistance to impact, of cast steel of a given composition can be materially improved by the quenching and drawing operation, it is not advisable to prescribe in a general specification a set of physical properties which cannot be obtained by a simple annealing treatment.

Second.—Interior defects and irregularities of steel castings are very apt to make the quenching operation exceedingly dangerous as regards development of cracks, it being practically impossible to quench castings of certain design without the development of checks and cracks, which may not always be apparent upon surface examination.

Third.—A casting which has been quenched and drawn can be very advantageously used for many purposes if the design will permit of its proper treatment. In case the heat treatment of a given casting is desirable in order to obtain better physical properties, a study should be made of the casting in question and special physical requirements and specifications developed for each individual case.

Obituary.

CAPT. G. E. GIBBONS, of Gibbons (Dudley), Limited, died on March 20, in his 27th year.

MR. R. DOWNING, iron and steel merchant, of Barnsley, died recently as the result of an accident. The deceased gentleman was in his 36th year.

MR. HY. HIRST, who along with his father, the late Mr. Arthur Hirst, founded the firm of A. Hirst & Son, Limited, Crescent Works, Dewsbury, in 1889, died on the 4th inst. at his residence, Crescent House, Moorlands Avenue, Dewsbury, after a long illness. He was 59 years of age.

American Tariff Inquiry into Iron and Steel Costs.—The U.S. Tariff Commission is seriously considering the making of a survey of the steel industry in the United States and competing countries to ascertain the difference in costs of domestic and foreign production. Decision in the matter only awaits President Harding's return to Washington. The Commission would seek the information through a plan of co-operation and not through any attempt at force. Any broad investigation that might be undertaken would call for active field work in Great Britain, France, Germany, Belgium, Luxemburg, and probably Sweden, Czecho-Slovakia, Spain and Austria. The inquiry regarding pig-iron costs and any general iron and steel study that may be determined upon will be under the direction of a staff in charge of Mr. Paul M. Tyler, chief of the Metals Section of the Tariff Commission, which comprehends both ferrous and non-ferrous ores and manufactured products. He will go abroad with a staff which will include Mr. F. M. Leonard, in charge of the Iron and Steel Subdivision, and Mr. W. J. Spencer, of the Iron and Steel Section of the Commission. Some of the Commission's investigations are expected to start May 1, and it may be that the iron and steel inquiry can be begun on that date.

XUM

New Development in Cupola Construction.

A new development in cupola construction is presented by the Schuermann cupola which is described in the issue of *Die Giesserei*, No. 18 for 1922. The author of the article is E. Hellmund, operating manager of the Werner Iron & Steel Company, Duelken, Germany, where working tests were carried out. The inventor was formerly owner of a foundry at Coswig, and has protected his cupola by German Patent No. 266,303. The objects desired are a shortening of the time during which the melting iron is in contact with the glowing coke and more especially the ascending column of gases, and also a preheating of the blast. When first introduced to foundrymen the proposed new cupola attracted very little interest, but it was decided to make a practical test at the Werner plant.

Fig. 1 shows a typical diagram of a Schuermann cupola. The blast enters through the reversing valve *a*, passes through chamber *b* of the pre-heater, enters the cupola at *c* and enters into combustion with the coke. The waste gases pass through the chamber *e*, thereby heating it, then through the reversing valve *a* and the throttle valve *f* to the chimney *g*. As well as through the openings square across the cupola, a part of the blast is at the same time carried through two tuyeres arranged at the sides so as to cover the total space.

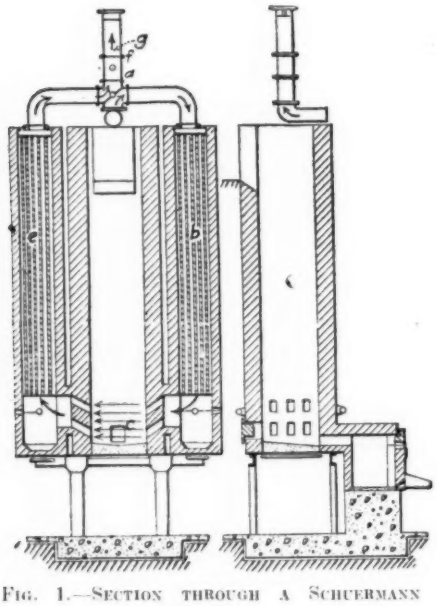


Fig. 1.—Section through a Schuermann Cupola.

As the result of tests which have been carried far enough to be considered conclusive, the amount of coke needed is from 6.5 to 7.5 per cent., depending on the kind of castings to be made. In most cases the iron had to be strongly over-heated for their thin-walled castings, but even then they never used more than 7.5 per cent. coke. For the first 15 charges they used 7 per cent. and for the following 15 charges 7.50 per cent. They work 48 hours per week, only 5 days in the week; following this the chambers for heating the blast remain cold Saturday and Sunday with no auxiliary fire, only the throttle valve remains always closed. Even then when starting up Monday morning it is not necessary to use for the first charges more than 7 per cent. coke. The monthly coke consumption with normal cupola operation used would be as follows:—.

15 tons × 20 = 300 tons charge with 10.6 per cent. coke. This = 31.8 tons. To-day 300 tons × 7.25 per cent. = 2,175 tons, showing a saving of 10 tons in the month.

This amounts to 120 tons per year, which, with the present price of coke, including freight, cost of unloading, etc., equals a very large amount per year. In addition to the saving of coke the quality is improved, due to the lowering of the sulphur by 20 to 30 per cent.

Figs. 2 and 3 show the automatic records of amount and pressure of blast. As may be clearly seen reversals were carried out every 10 min. During the period *a* reversals were at 3-min. periods in order to burn the the coke bed and also heat the two chambers. The period *b* shows the time of the first charge, while *c* shows the normal running. In period *d* the blast was taken off while the slag tap was closed. The final period *e* shows the blast

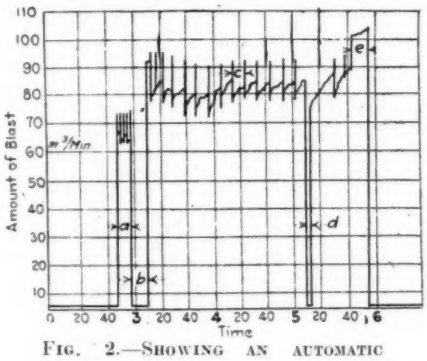


Fig. 2.—Showing an automatic record of the amount of blast used.

entering from both sides. The temperature of the waste gases leaving the chimney stack was about 100 to 150 deg. C., which is a proof that the brickwork of the chambers was absorbing the greatest part of the heat. The melting ran along without trouble and the reversals prevented a slagging of the tuyeres.

It is hoped to decrease, even more than at present, the amount of blast passing upward through the column of charge, which it is believed will still further reduce the coke consumption, because the carbon of the coke will not be acted on by the carbon dioxide. Shortly after starting the gases pass from the heating chamber to the cupola at about 400 deg. C. After two or three reversals the blast temperature reaches about 800 to 900 deg. C.

In order to use the carbon monoxide present in the waste gases, a small amount of blast is introduced in the heating chambers. The results show that for about 3 months the highly heated iron necessary for thin castings has been produced without trouble or other bad effects and with, at the most, a coke charge of 7.5 per cent. At the same time the sulphur of the iron has shown a reduction up to 30 per cent., which results lead to the con-

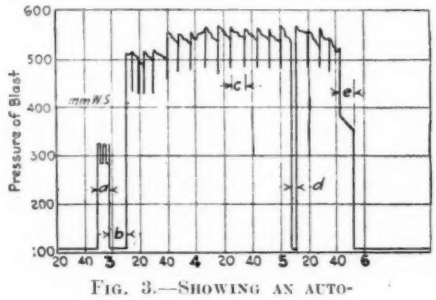


Fig. 3.—Showing an automatic record of the blast pressure during a blow with the Schuermann cupola.

clusion that a remarkable improvement has been reached in the cupola melting practice. The writer of the German article believes no such fundamental change in cupola practice has been seen for the last century.

In the table are given the results of a two weeks' test which began with a coke charge of 8 per cent., a coke bed of 1,650 lbs. with a blast pressure of 7.5 to 10 ozs. Higher pressure was not possible with the blowing arrangement available. The amount of blast amounted to 2,650 to 3,000 cub. ft. per min. The entering blast was from 400 to 900 deg. C., the

waste gas temperature 100 to 150 deg. C., the charge 10.5 metric tons. The blast was begun at 3.20 and ended at 6.30, so that the rate of melting was about 3.4 tons per hr. The rate of melting in this case was too small and could not be much increased during the two test weeks. This was because the side tuyeres, mentioned above, were arranged in the brickwork of the cupola and could not be changed during this period.

The sulphur content of the molten iron showed during 5 days with 7 per cent. coke, a decrease from 0.14 to 0.11 per cent., which equals about 20 per cent. During the whole test period, with the exception of 4 days when they had 1,540 lbs. of cold iron which could not be cast, they had uniformly over-heated iron which gave good castings. During the test period they got down to 6.5 per cent. coke, and even during the last day had no trouble from cold iron, notwithstanding a 33-min. delay from stoppage of current.

In the table the various sulphur results are shown and on the average the decrease amounts to 20 to 30 per cent. It also must be remembered that they melted with a shaft furnace. In a furnace with a fore-hearth the final sulphur would have been still smaller.

The test period showed the changes necessary to be made. To-day they have a rate of melting of 5¼ tons per hr. and are in the position to possibly increase this through increasing the size of the side tuyeres, but this is not desirable for their practice as they would not be able to cast the extra metal so provided. No disadvantages of the new method of melting have been found up to the present time. The heating chambers are clean and show no effects of the heat, which will probably be seen after a year in operation. It is assumed that the life of these chambers will be at least 5 years. It is also assumed that, with normal working, the cost of the plant for a daily output of 15 tons will be covered by the saving in coke in one year's operation.

Table of Test Results of Cupola Operation with Hot Blast.

Coke charge, per cent.	Coke bed, lbs.	Blast. Pressure, in ozs.	Blast. Amount, cub. ft. per min.	Blast. Deg. C.	Waste gas, Deg. C.	Run. Begun.	Run. Ended.	Charge, in lbs.	Sulphur, per cent. 1	Sulphur, per cent. 2	Sulphur, per cent. 3
8.0	1,650	7.5 to 10.0	2,650 to 3,000	400 to 900	100 to 150	3:20	6:30	23,150	—	0.101	0.089
7.0	1,650	8.6 to 11.2	2,650 to 2,900	400 to 900	100 to 150	3:10	6:10	20,390	0.112	0.11	0.075
6.5	1,650	8.0 to 10.8	2,540 to 2,900	400 to 900	Charge 15 had 7 per cent. coke.	2:50	6:10	22,600	0.120	0.111	0.086
6.5	1,650	8.2 to 10.0	2,650 to 3,000	400 to 900	15,430 lbs. cold iron	2:55	6:25	25,350	0.110	0.112	0.080
7.0	1,650	8.6 to 11.2	2,650 to 3,180	400 to 900	——	2:40	6:00	24,800	0.135	0.14	0.112
6.5	1,650	10.5 to 11.5	2,650 to 3,000	400 to 900	Charge 14 had 7 per cent. coke.	3:10	6:00	18,200	0.156	—	0.079
6.5	1,650	10.0 to 11.5	2,820 to 3,000	400 to 900	Charge 15 had 7 per cent. coke.	2:38	6:20	25,900	0.130	0.104	0.083
6.5	1,650	10.0 to 11.5	2,820 to 3,040	400 to 900	——	3:10	5:55	21,500	0.136	0.076	0.062
6.5	1,650	10.8 to 11.2	2,970 to 3,040	400 to 900	——	2:55	5:55	25,350	0.134	0.083	0.055
6.5	1,650	10.5 to 10.8	3,000 to 3,180	400 to 900	33 min. stoppage of current.	2:50	6:15	25,350	—	—	—

This paper was read at a meeting of the German Foundrymen's Association on April 27, at Duesseldorf, and was followed by an active and interesting discussion. The presiding officer, Dr. Werner, said that the new cupola had been brought to the attention of the German Foundrymen's Association during the war, but nobody was interested in it, and the inventor made the proposal that the cupola would be available to all the German foundrymen without licence, except for covering the heavy costs already incurred for home and foreign patents. Dr. Werner, after investigation, made up his mind to try the cupola in their plant at Duelken, and the paper abstracted above gives the results obtained. It is certain that the final construction of the cupola has not been reached, but, as built for the test run, has shown splendid results. The Schuermann Company has designed a new construction.

During the discussion one question asked was whether the heating chambers did not need frequent cleaning. The reply was that during the three months' operation this had not been found necessary. In reply to another question it was stated that the cupola had a diameter of 35.4 to 39.4 in. Another speaker pointed out that spark arresters would not be necessary and the three months' operation had shown no danger of explosions. Uncompleted tests showed that the gases leaving the combustion chamber have about 5 per cent. CO with 13 to 14 per cent. CO_2. Mention was made of the danger of explosions, but it was believed that with suitable doors to guard against explosions this could be avoided.

The heating chambers are constructed of firebrick exactly the same as for the stoves of a blast-furnace. Also after each day's run the cupola lining is fixed up, and after the three months' run a complete new lining was put in. Another speaker mentioned he had carefully followed the operations in Duelken and could corroborate the results obtained. One point he wished to make was that with the small amount of coke, only 35 kg., for a charge of 500 kg., very uniform distribution must be used. The dust that collects in the brickwork of the heating chambers is easily removed by means of compressed air. He believed this style of cupola would be especially suitable for small Bessemer plants because no sulphur was taken up from the coke and probably large amounts of scrap could be melted. In reply to another question it was stated that the average charge consisted of 50 per cent. pig-iron and 50 per cent. scrap iron castings. —"Iron Age."

Presentation to Mr. Hogg.

A meeting of the Lancashire Branch was held on April 7 at the Municipal College of Technology, Manchester, Mr. J. Haigh presiding. The President of the Institution, Mr. H. L. Reason, was present. In opening the proceedings the Chairman said Mr. Reason had made this visit for the express purpose of taking part in the presentation which the members were making to Mr. J. Hogg in recognition of his services to the Branch in the position of honorary secretary. It was unnecessary to dwell upon the value of those services. They all knew very well the amount of hard work which Mr. Hogg put in, and they were proud of him and of what he had done.

Mr. Reason then presented Mr. Hogg with a case of cutlery.

His particular duty at the moment was a very happy and pleasant one—to make the presentation to Mr. Hogg on behalf of the Branch. That duty might have been assigned to the Branch-President, and as a past-Branch-President he knew the value of good secretarial work. No doubt at the same time he had derived much pleasure from the work. His indomitable pluck and perseverance were shown in the way in which he had won through from the stage of practical training in the workshop to the post of director. It should also be placed on record that it was largely due to his efforts that the Burnley Branch was formed.

On behalf of the Lancashire Branch, and he might say of the whole Institution of British Foundrymen, he presented to Mr. Hogg this small token of appreciation of his invaluable services. Its intrinsic value bore no relation to the feeling, affection, and regard with which he was held by every member.

Mr. Hogg's Reply.

Mr. Hogg, in returning thanks for this magnificent present, said the feeling uppermost in his mind was one of affection for the Lancashire Branch. His connection with it had been of great assistance to him in his career; if he could bring home to everyone present the help he derived from the letters which came to him from members of the Institution, outside the Lancashire area as well as within it, it would certainly increase the regard they had for the Institution. His own sentiments he could not adequately express, but he would do his best, as long as it was in his power, to show how he valued his association with the other members and the kindness they had shown him during his term of office and on this occasion.

Trade Talk.

Mr. A. Harris has removed from 285, Broad Street, Birmingham, to the Crucible Works, Morville Street, Ladywood, Birmingham.

The Nos. 3 and 5 blast furnaces at Victoria, Ebbw Vale, of the Ebbw Vale Steel, Iron & Coal Company, Limited, were blown in on April 7.

The North Skelton ironstone mines of Bolckow, Vaughan & Company, Limited, which have been idle for the past two years, were re-opened on Monday.

The Machine Tool Trades Association proposes to hold its third Machine Tool and Engineering Exhibition at Olympia, London, in September of next year.

The No. 3 blast furnace was lighted at the Normanby Park Steelworks of John Lysaght, Limited, on April 10. There are now five furnaces in blast at the Normanby Park works.

During the first three months of this year there have been launched by Belfast shipbuilders four vessels, of 54,000 tons—the same number of ships as during the corresponding period of last year, but an increase in tonnage of 16,000.

F. Warburton & Company, 10, Bush Lane, Cannon Street, London, E.C.4, have been appointed selling agents for the Royal Nederlandsche Lood-en Zinkpletterijen Voorheen A.D. Hamburger, Utrecht, Holland, lead and zinc manufacturers.

Mr. A. E. Dowell, assistant works manager at Scotswood Locomotive Works, has been awarded the gold medal of the Institute of Locomotive Engineers for a paper which he read before the members in "Modern Production and Costing Methods."

James Allan, Senior, & Son, Limited, of Glasgow, have secured the order for the supply of all the structural steelwork required for the construction and equipment of the general workshops of the Portuguese South and South-Western Railway at Barreiro.

Meldrums, Limited, Engineering Works, Timperley, nr Manchester, secured 19 orders during February for forced-draught furnaces, including forced draught to two reverberatory furnaces at a steelworks, which is a repeat order. Refuse destructors orders have been secured from three concerns.

Licences under the Non-Ferrous Metal Industry Act, 1918, have been granted to Bekhout & Company, Limited, 94, Hope Street, Glasgow; Jenkins, D. J., trading as D. J. Jenkins & Company, St. Clement's Chambers, Briton Ferry; John Needham & Sons (Manchester), Limited, 15, Cross Street, Manchester.

Sir John C. Davies, J.P., managing director of Baldwins, Limited, was at the Works Institute, Landore, recently, the recipient of a presentation by the officials and workmen of Baldwins, Limited, and associated companies, in commemoration of the knighthood conferred upon him last November.

The council of Sheffield Association of Metallurgists and Metallurgical Chemists announce that the lease for the premises in West Street, Sheffield, where the Metallurgists' Club is to be established, has now been signed, and the furnishing and decoration are now being carried out. When this work is complete, there will be an official opening.

Vickers, Limited, have secured an order from the Anglo-Newfoundland Development Company for a large steamer which will be built at their yard in Barrow-in-Furness and completed early next year. She will be fully 400 ft. in length, with a speed of over eleven knots, a displacement of 13,000 tons, and a capacity for carrying about 5,000 tons of paper in rolls.

For the first quarter of the year the launches on the Wear were considerably below the average, as only four vessels, aggregating 14,562 gross tons, left the berths, whereas in the first quarter of the previous year ten vessels, totalling 45,379 gross tons, were launched, while in the like period of 1921 the launches numbered seven and the gross tonnage was 14,160. There are several vessels almost ready to launch, but no new orders are reported.

The British Engineers' Association have issued a ground plan showing the progress of space-letting in their shipbuilding, marine, mechanical and general engineering section of the British Empire Exhibition, covering an area of 217,000 square feet, in the Machinery Hall. The first allotment of space was made a fortnight ago, and the coloured plan shows in a striking manner the remarkable progress already achieved in the sale of stand space.

Mr. J. T. Atkinson, secretary of the Cleveland Ironmasters' Association, announces that the ascertained price of No. 3 Cleveland pig-iron for January, February, and March was 92s. 10.69d. Under the blast-furnacemen's wages sliding scale agreement, the price named will give an advance of 4.50 per cent. for the ensuing quarter. The advance will take effect from April 1. The price for the fourth quarter of 1922 was 88s. 4.74d., therefore there has been an advance in price of 4s. 5.95d. per ton in the first quarter of the current year

Company News.

Hadfields, Limited.—Final dividend, 6d. per share, making 5 per cent. for year, tax free.

D. Howard & Company, Limited, 328, Royal Liver Building, Liverpool.—Capital £5,000 in £1 shares. Engineers.

Cedos Engineering Company, Limited, West Bridge, Northampton.—Capital £25,000. Directors: D. N. Campbell and E. Smith.

Nantyglo and Blaina Ironworks Company, Limited.—Dividend £2 per share on 8 per cent. preference shares on account of arrears.

Birmingham Small Arms Company, Limited.—Dividend on A preference 5 per cent. per annum, with B preference 6 per cent. per annum.

Fraser & Ellis, Limited, 12, Portsea Mews, Portsea Place, Marble Arch, London, W.—Capital £10,000 in £1 shares. Ironfounders' merchants.

Coliseum Engine Company, Limited, 30, Finsbury Court, London, E.C.—Capital £100 in 2s. shares. Directors: H. Dixon and H. Wallace.

Muir, Murray & Company, Limited, Adelphi Works, 80, New Sneddon Street, Paisley.—Capital £6,000 in £1 shares. Engineers and furnace builders.

Nicholson Bros., Limited, 56, Roberts Street, Grimsby.—Capital £5,000. General engineers, etc. Directors: C. F. Nicholson and G. W. Parker.

Oates Bros., Limited.—Capital £6,000 in £1 shares. General engineers. Directors: A. E. Oates, R. G. Oates, R. H. Belt and R. I. Bainbridge, Thornton Hall, High Coniscliffe, Darlington.

J. & J. Woods, Limited.—Capital £15,000. Brass and iron founders. Permanent governing director and chairman: J. Woods, Woodbine Villa, Rainhill, Lancs.

H. H. Vivian & Company, Limited.—Surplus £1,138 brought forward converted into adverse balance £629, after providing for debenture interest; deficit charged to reserve fund.

Butts Foundry Company, Limited.—Capital £2,000 in £1 shares (1,000 5 per cent. cumulative preference), to acquire the business of malleable iron and brass founders carried on by C. Cooper and F. Pitt as "Pitt & Cooper," at William Street, Walsall, and elsewhere.

Expert Die-Casting Company, Limited, The Osiers, Point Pleasant, Wandsworth, London, S.W.18.—Capital £4,000 in 6,000 ordinary shares of 10s. and 1,000 10 per cent. participating preference shares of £1. Directors: H. W. Hollands, R. A. Richards and R. T. Gates.

Gazette.

C. H. Taylor & Son, Limited, Leeds, ironfounders, in liquidation. Mr. J. Barker, Atlas Chambers, King Street, Leeds, I.A., has been appointed receiver.

Nene Engineering Company, Limited, Peterborough, in liquidation. Mr. J. Stephenson, Queen Street Chambers, Peterborough, I.A., has been appointed receiver.

Trading under the style of Childs & Wright, Messrs. T. R. Childs, H. F. Wright, and A. P. Oldham, Tresham Street, Kettering, engineers, have dissolved partnership. Debts by Messrs. T. R. Childs and H. F. Wright, who continue the business.

The partnership hitherto subsisting between Messrs. C. Chorley and R. J. Chorley, Warrington, trading as J. Chorley, iron and steel merchants, has been dissolved. Debts by Mr. R. J. Chorley, who continues the business.

Trading under the style of Smith & Greenwood, Messrs. G. Smith and T. Greenwood, Mills Street Engineering Works, Heywood, engineers, have dissolved partnership. Debts by Mr. T. Greenwood, who continues the business.

Notices.

Trading under the style of J. J. Bennett & Son, Mr. J. J. Bennett, 88, Mosley Street, Manchester, metal merchant and broker, intimates that the business has been transferred to Mr. E. H. Bennett, who will continue to carry it on under the old style at same address. Mr. J. J. Bennett will pay and receive all accounts of the business up to and including December 31, 1922.

Dimity Foundry Company (Mr. J. Smith), Dimity Street, Johnstone, ironfounders. The business has been sold and transferred to Mr. T. W. Somerville, Johnstone, engineer, who will carry it on for his own behoof, and will be responsible for all debts contracted from the date of the transfer. Mr. J. Smith will collect all accounts due to him, and will also pay all debts due by him to that date.

The . . .

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Pig-Iron Manufacturers.

Suitable for all

GENERAL FOUNDRY PURPOSES.

Brands: STAVELEY and RINGWOOD.

The Services of our expert Metallurgical Staff are at Buyers' disposal.
We are prepared to advise suitable mixtures, for all foundry purposes.

CAST IRON PIPES

of all sizes for Water, Gas, Steam and Hydraulic Pressure.

WOOD WOOL

for Filtration, Packing and other purposes.

Chemical Manufacturers:

Aniline Oil,
Aniline Salt,
Naphthaline Balls,
Naphthaline Tablets,
Hot Pressed Naphthalene,
Naphthalene Flakes,
Naphthalene Powder,
Cresylic Acid,
Crude Carbolic Acid,
Nitre Cake,
Salt Cake,
Pyridene
Sulphate of Copper,
Sulphate of Iron,
Red Oxide of Iron,
Bleaching Powder,
Caustic Soda,
Accumulator Acid,
Creosote Oil,
Green Oil, Pitch,
Sulphate of Ammonia,
Muriate of Ammonia,
B.O.V. & R.O.V.
Oleum (all strengths),
Pure Sulphuric Acid,
Nitric Acid,
Disinfectant Powder.

TARRED SLAG.

"STAVEHO" For Making Cement Work Waterproof.

PLEASE WRITE FOR PRICES.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Business in the Cleveland iron markets remains practically in the same position as last reported, heavy purchases of late, both on home and export account, having completely exhausted the already depleted stocks, while makers, with few exceptions, are fully committed over the second quarter. Unfortunately, the question of fuel supplies still prevents expansion of output to meet the increasing demand, and while the present scarcity, due to the heavy calls of Continental users, continues, there is but a faint prospect of more furnaces going into blast. This is the more regrettable, as several furnace plants in the Tees-side district are ready for relighting, when fuel supplies are available. Meanwhile, prices are all very firmly held at recent levels. No. 1 is 132s. 6d., No. 3 G.M.B. 127s. 6d., No. 4 foundry 125s., and No. 4 forge nominally 120s. to 122s. 6d.

The markets for hematite, in contrast to those for ordinary iron, disclose an easier tendency, although prices on the East Coast are not quotably lower, but on the West Coast next month's business can be put through at £6 15s., whereas £7 and £7 2s. 6d. was wanted recently. Makers without exception are well off for orders, and their difficulty is that they are not getting heavy enough deliveries of coke to enable them to expand their output, several furnaces being ready for lighting. There is little iron for prompt disposal, and then only at a figure higher than £6 15s. Business has been steady, with orders being booked for delivery into the summer months. For special iron there is a good demand.

THE MIDLANDS.—Supplies of pig-iron available for consumption in this area continue restricted, most makers being well sold forward, and having nothing to offer for prompt sale. Occasionally a limited tonnage of iron for immediate delivery comes into the market, and for this smelters can obtain their own price, for there are plenty of eager customers. Apparently there is a substantial volume of business to be done, but no one seems to be in a position to take full advantage of the inquiry. Supplies of fuel are still inadequate for the furnaces in operation, and consequently the prospect of additional plants being put into operation is even more remote than ever. In circumstances such as these it is not surprising to find that quotations are very firm, with a tendency to go still higher.

SCOTLAND.—Movements in the Glasgow iron market of late have taken a much quieter turn, and although the export returns are fairly satisfactory—the tonnage shipped from the Clyde last week having shown a big increase over the corresponding week last year—home consumers have a tendency to hold off in anticipation of obtaining more favourable terms shortly. Second-hand dealers, however, are inclined to shade prices with a view to securing profits on cheap purchases, in case the market should ultimately slump. There are a number of inquiries coming into the market for export, but there is not much business resulting.

Finished Iron.

The recent quarterly meeting at Birmingham disclosed a well-maintained demand for finished iron of all kinds. Marked bar makers are receiving improved support from engineering and shipbuilding customers, and there is also a fairly good export demand. Naturally complications on the Continent have diminished the usual competition experienced from that source, and foreign buyers are turning attention to British material. The recent advance in the basis for marked bars was a very moderate one, and it did not prevent makers putting another 10s. on. Crown bar makers also reported very favourably of their experience. Demand is greater than they can cope with, in view of the fact that their output is frequently restricted temporarily, owing to lack of fuel. Under such circumstances they have no difficulty in obtaining £12 10s. for good-quality bars. The disappearance of foreign competition and the advance in prices in other districts have been very helpful to makers of commoner iron for nut and bolt making, and they now have no difficulty in obtaining £11 15s. for these qualities of material.

Scrap.

Reports from the various centres of the trade in scrap material indicate continued firmness on the whole, although in some cases buying has been on a more restricted scale. In Lancashire, for example, the demand for cast-iron scrap is very poor at the moment, and although it is offered at 20s. below its real value, dealers find great difficulty in selling. This position confirms the report that ironfounders are now, as a rule, very short of orders for new castings, for if they were busy they would certainly use as much scrap as possible in all their mixings.

Steel.

Convincing evidence of the existing activity in most branches of the steel industry is afforded in the early termination of the Easter holidays, which, usually extending from seven to fourteen days, have on this occasion been restricted generally to a few days only. On the other hand, makers confirm a falling off in some directions in volume of orders, and it has been discussed whether these conditions are due to the recent advances in the price of steel and steel-making materials, or in consequence of rumours of an early evacuation of the Ruhr and the return of business to that locality for which other sources of supply have been sought during the period of occupation. Sufficient is it to say that alloy prices are mounting rapidly.

Metals.

Copper.—Quiet conditions have prevailed in the market for standard copper during the past week, buying having been mostly confined to home consumptive requirements over the end of the current month. The underlying tone, however, is fairly good, and a feeling of quiet optimism prevails, but until buying is resumed on a larger scale values are not likely to improve. Little business has been transacted with the Continent, while a further reduction in stocks is reported in America owing to the record deliveries during March, but with producers making every effort to increase production a further buying movement will be necessary to retain the present strong statistical position of the metal. Current quotations :—*Cash* : Wednesday, £73 10s. ; Thursday, £73 ; Friday, £73 2s. 6d. ; Monday, £73 7s. 6d. ; Tuesday, £73 5s. *Three Months* : Wednesday, £74 7s. 6d. ; Thursday, £73 15s. ; Friday, £73 17s. 6d. ; Monday, £74 ; Tuesday, £74 2s. 6d.

Tin.—Movements in the market for standard metal have been inclined to erratic fluctuations of late, profit-taking and absence of buying by American consumers having been the chief causes of the decline, but the present levels are attracting buyers, and latest American cables report an improvement in the market there. A reaction from the high level recently reached was anticipated, but, as the demand from consumers continues good, it is not expected that it will be of long duration. With reference to the rumour recently current that the Federated Malay States Government had disposed of its stocks of tin held under the Bandoeng Agreement, the Malay States Information Agency is authorised to state that there is no truth in such rumour.

As has been already announced, the Government of the Federated Malay States has no intention of selling its stocks of tin otherwise than in small quantities to meet the consumptive demand whenever attracted by suitable prices. Current quotations :—*Cash* : Wednesday, £218 15s. ; Thursday, £217 ; Friday, £215 10s. ; Monday, £214 ; Tuesday, £211 15s. *Three Months* : Wednesday, £219 10s. ; Thursday, £217 5s. ; Friday, £216 5s. ; Monday, £214 7s. 6d. ; Tuesday, £212.

Spelter.—Values in this market have developed a drooping tendency of late, there having been very little inquiry from consumers, who appear to be content to cover their requirements only when necessary. Belgium is still offering sufficient quantities to keep this market well supplied, while America, despite a slight weakening, is still without influence on the London market. Current quotations :—*Ordinary* : Wednesday, £35 12s. 6d. ; Thursday, £34 15s. ; Friday, £35 ; Monday, £35 ; Tuesday, £34 12s. 6d.

Lead.—The industrial situation in the building trade has had an adverse effect upon the market for soft foreign pig, and in consequence values have declined. Arrivals have been plentiful, and consumers have been able to continue their policy of buying hand-to-mouth without being charged high premiums for spot metal. The American market still shows no signs of weakening, and producers seem to be well sold for April delivery. Current quotations :—*Soft foreign (prompt)* : Wednesday, £27 12s. 6d. ; Thursday, £27 2s. 6d. ; Friday, £27 ; Monday, £27 7s. 6d. ; Tuesday, £27 10s.

the right Fan

is the one that does the work and does it well with the minimum running cost. From the wide range of various designs of

Submit your Fan Problems to us.

Mechanical Boiler draught, Ventilation, Blowing Cupolas, Dust Removal, etc.

···TRADE··· SIROCCO ···MARK···

Centrifugal Fans

we can select the right Fan for your purpose because we have a thorough knowledge of Fan applications, acquired by years of experience.

Your requirements are first carefully studied and the Fan then selected that will do the work efficiently through a long life of hard service.

DAVIDSON & CO., LIMITED,

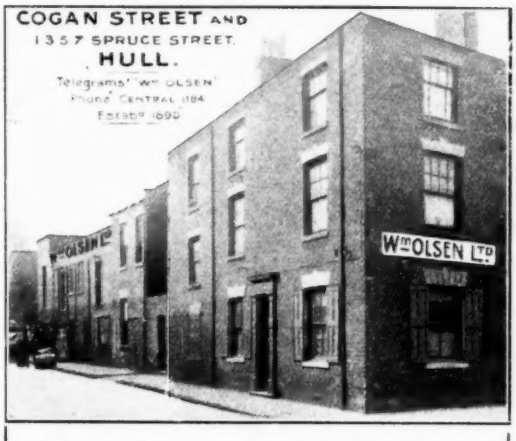
Sirocco Engineering Works, BELFAST.

TINPLATES, BLACKPLATES, TERNEPLATES.

For Prices apply with Specification to :

OSCAR MOENICH & Co. Ltd.,

Billiter House, Billiter Street, London, E.C.



The House for Plumbago

and everything for the Foundries.

SOAPSTONE, Parting Powder, CORE GUM, etc.

Samples and Prices on application.

William Olsen, Ltd., HULL.

Swift — Metallic — Stopping

THE BRITISH FOUNDRY CEMENT for filling up Blow Holes in Castings. It dries in one hour and it can be filed up from 6 to 12 hours.

SAMPLE FREE—AGENTS WANTED.

THE SILENT MACHINE CO., Savile Street, SHEFFIELD.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	73	5	0
Three months	74	2	6
Electrolytic	81	0	0
Tough	76	10	0
Best selected	76	10	0
Sheets	106	0	0
India	93	0	0
Wire bars	81	5	0
Do. Apr.	81	5	0
Do. May	81	5	0
Ingot bars	81	5	0
H.C. wire rods	86	0	0
Off. aver., cash, Mar.	73	18	4
Do. 3 mths., Mar.	74	12	2½
Do. Settlement Mar.	73	18	1½
Do. Electro, Mar.	81	14	7½
Do. B.S., Mar.	77	7	9½
Aver. spot price, copper, Mar.	73	17	3¾
Do. Electro, Mar.	82	0	0

Solid drawn tubes 14¾d.
Brazed tubes 14¾d.
Wire 11½d.
Yellow metal rods 7½d.
Do. 4x4 Squares 9d.
Do. 4x3 Sheets 10d.

BRASS.

Solid drawn tubes 13d.
Brazed tubes 14½d.
Rods, drawn 11½d.
Rods, extruded or rolled 7½d.
Sheets to 10 w.g. 11d.
Wire 11d.
Rolled metal 10½d.

TIN.

	£	s.	d.
Standard cash	211	15	0
Three months	212	0	0
English	211	15	0
Bars	213	15	0
Chinese	211	0	0
Straits	221	15	0
Australian	216	15	0
Eastern	220	0	0
Banca	215	5	0
Off. aver., cash, Mar.	219	15	0
Do. 3 mths., Mar.	220	18	10⅛
Do. Sttlment, Mar,	219	15	0⅞
Aver., spot, Mar.	219	13	4

SPELTER.

	£	s.	d.
Ordinary	34	12	6
Remelted	32	0	0
Hard	28	0	0
Electro 99.9	40	10	0
English	35	10	0
India	29	0	0
Prime Western	35	0	0
Zinc dust	49	10	0
Zinc ashes	13	10	0
Off. aver., Mar.	36	15	4½
Aver., spot, Mar.	36	14	4¾

LEAD.

	£	s.	d.
Soft foreign ppt	27	0	0
English	28	0	0
Off. average, Mar.	28	15	1¼
Average, spot, Mar.	28	16	3¾

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	43	0	0
Do. V.M. ex whf.	42	0	0
Dutch	42	0	0
Rods	50	0	0
Boiler plates	41	0	0
Battery plates	42	0	0

ANTIMONY.

	£	s.	d.
English regulus	30	10	0
Special brands	36	15	0
Chinese	27	10	0
Crude	20	0	0

QUICKSILVER.

Quicksilver £11 2 6

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
45/50% £13 2 6
75% £20 17 6
Ferro-vanadium—
35/40% 17/- lb. va.
Ferro-molybdenum—
70/75% c. free 9/6 lb. mo.
Ferro-titanium—
23/25% carbonless 1/2½ lb.
Ferro-phosphorus, 20/23%, £28 10
Ferro-tungsten—
80/85%, carbon free 1/5½ lb.
Tungsten metal powder—
98/99% 1/10½ lb.
Ferro-chrome—
4/6% car. £23 10
6/8% car. £22 10
8/10% car. £21 10
Ferro-chrome—
Max. 2% car. £52 0
Max. 1% car. £62 0
Max. 0.70% car. £72 0
67/70%, carbonless 1/6½ lb.
Nickel—99%, cubes or pellets £130 0
Cobalt metal—98/99% 12/-lb.
Aluminium—98/99% £110
Metallic Chromium—
96/98% 4/6 lb.
Ferro-manganese (net)—
76/80%, loose £18
76/80%, packed £19
76/80%, export £18
Metallic manganese—
94/96%, carbonless 2/- lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% s. d.
tungsten 2 6
Finished bars, 18% tungsten 3 0
Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ¾ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness 3d. lb.
Bevels of approved sizes and sections.. 6d. lb.
If in coils.. 3d.lb.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces 3d.
Turnings and swarf 1d.
Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy steel	5	5	0	5	10	0
Bundled steel & shrngs.	4	10	0	5	5	0
Mixed iron & steel..	4	10	0	4	15	0
Heavy cast iron				4	12	6
Good machinery for foundries				4	10	0

Cleveland—	£	s.	d.
Heavy steel	4	15	0
Steel turnings	3	7	6
Cast-iron borings	3	7	6
Heavy forge	5	10	0
Bushelled scrap	5	0	0
Cast-iron scrap	5	2	6

Lancashire—	£	s.	d.
Cast-iron scrap	5	0	0
Heavy wrought	5	5	0
Steel turnings	3	12	6

London — Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	67	0	0
Brass (clean)	40	0	0
Lead (less usual draft)	25	0	0
Tea lead	23	0	0
Zinc	23	10	0
New aluminium cuttings	70	0	0
Braziery copper	58	0	0
Gun metal	50	0	0
Hollow pewter	180	0	0
Shaped black pewter	100	0	0

PIG-IRON.

N. E. Coast—	
Foundry No. 1	132/6
Foundry No. 3	127/6
Forge No. 4	121/3
Mottled	—
Hematite No. 1	128/6
Hematite M/Nos.	127/6
Midlands—	
Staffs. common	—
,, part-mine forge	—
,, ,, foundry	—
,, Cold blast, ord.	190/-
,, ,, roll iron	200/-
,, basic	—
Northants forge	100/-
,, foundry No. 3	110/-
,, basic	110/-
Derbyshire forge	107/6
,, foundry No. 3	115/-
,, basic	115/-
Scotland—	
Foundry No. 1	125/-
,, No. 3	120/-
Hematite M/Nos.	127/6
Sheffield (d/d district)—	
Derby forge	111/-
,, foundry No. 3	121/-
Lincs. forge	110/-
,, foundry No. 3	117/6
,, basic	—
E.C. hematite	137/9
W.C. hematite	135/-
All d/d in the district.	
Lancashire (d/d eq. Man.)	—
Derby forge	—
,, foundry No. 3	132/6
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	—
,, foundry No. 3	—
Dalzell, No. 3	137/-
Summerlee, No. 3	137/-
Glengarnock, No. 3	137/-
Gartsherrie, No. 3	137/-
Monkland, No. 3	137/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (cr.) £12 to	12	10	0
Angles	12	5	0
Tees to 3 united ins.	12	10	0
Nut and bolt	11	15	0
Hoops	15	0	0
Marked bars (Staffs.)	14	10	0
Gas strip £12/5 to	12	10	0
Bolts and nuts, ¾ in. × 4 in.	20	10	0

Steel—			
Ship plates	10	10	0
Boiler plates	14	0	0
Chequer plates	11	5	0
Angles	10	0	0
Tees	11	0	0
Channels	10	10	0
Joists	10	0	0
Rounds & squares 3 in. to 5½ in.	12	5	0
Rounds under 3 in. to ¾ in.	12	0	0
Flats, over 5 in. wide and up	12	10	0
Flats, 5 in. to 1½ in.	11	15	0
Rails, heavy	10	10	0
Fishplates	14	10	0
Hoops (Staffs.)	13	0	0
Black sheets, 24 g.	14	12	6
Galv. cor. sheets, 24 g.	19	10	0
Galv. fencing wire. 8 g. plain	18	5	0
Rivets, ¾ in. dia.	14	15	0
Billets, soft	10	0	0
Billets, hard	10	15	0
Sheet bars £9/11/6 to	10	0	0
Tin bars	10	0	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 4
Sheet	1 4½
Wire	1 5½
Rods	1 3½
Tubes	1 7
Castings	1 2

Delivery 3 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.
Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/4 to 1/10
To 18 in. wide	1/4½ to 1/10½
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6½ to 2/0½
Ingots for spoons and forks	9d. to 1/3
Ingots rolled to spoon size	1/- to 1/6
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	33.14
No. 2 foundry, Valley	31.00
No. 2 foundry, Birm.	27.00
Basic	32.77
Bessemer	32.77
Malleable	32.77
Grey forge	32.27
Ferro-manganese 80% delivered	125.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y, at mill	43.00
Bess. billets	45.00
O.-h. billets	45.00
O.-h. sheet bars	47.50
Wire rods	50.00
	Cents.
Iron bars, Phila.	2.82
Steel bars	2.50
Tank plates	2.50
Beams, etc.	2.50
Skelp, grooved steel	2.35
Skelp, sheared steel	2.35
Steel hoops	3.30
Sheets, black, No. 28	4.00
Sheets, galv., No. 28	5.25
Sheets, blue an'l'd, 9&10	3.25
Wire nails	2.90
Plain wire	2.65
Barbed wire, galv.	3.70
Tinplate, 100-lb. box	$6.00

COKE (at ovens).

Welsh foundry 40/- to 45/-
,, furnace 30/- to 35/-
Durham & North. fdy. 47/6
,, furnace 39/-
Other Districts, foundry 47/6
,, furnace 37/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C.Cokes,	20×14, box	25/9
,,	28×20, ,,	51/6
,,	20×10, ,,	35/-
,,	18¾×14, ,,	25/6
C.W.	20×14, ,,	24/6
,,	28×20, ,,	48/6
,,	20×10, ,,	33/3
,,	18¾×14, ,,	24/9
Terneplates	28×20, ,,	46/6

TUBES.

	Up to and incl. 6 in.
Gas ..	..57½% Tube prices
Water	..52½% are
Steam	..47½% now free.

SWEDISH IRON.

Bars, hammered basis sizes—Basis price £22 to £23

	£ s. d.
Rolled Ordinary—Assortment ..	£17 5 0
Nail Rods—Square, round and flats ..	to £17 15 0

Keg Steel nom. £38 to £40
Faggot Steel nom. £30 to £32
Blooms—Single welded .. £10 to £11
Billets—Single and double welded .. .. £13 to £14
Pig-iron—Grey, white or mottled £6 15 to £7 5 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
April 11	73	10	0	inc.	2/6
,, 12	73	0	0	dec.	10/-
,, 13	73	2	6	inc.	2/6
,, 16	73	7	6	,,	5/-
,, 17	73	5	0	dec.	2/6

Electrolytic Copper.

April 11	81	15	0	dec.	5/-
,, 12	81	0	0	,,	15/-
,, 13	81	0	0	No change	
,, 16	81	0	0	,,	,,
,, 17	81	0	0	,,	,,

Standard Tin (cash).

April 11	218	15	0	inc.	75/-
,, 12	217	0	0	dec.	35/-
,, 13	215	10	0	,,	30/-
,, 16	214	0	0	,,	30/-
,, 17	211	15	0	,,	45/-

Tin (English ingots).

April 11	219	0	0	inc.	80/-
,, 12	217	0	0	dec.	40/-
,, 13	215	10	0	,,	30/-
,, 16	214	0	0	dec.	30/-
,, 17	211	15	0	dec.	45/-

Zinc Sheets (English).

April 11	43	0	0	No change	
,, 12	43	0	0	,,	
,, 13	43	0	0	,,	
,, 16	43	0	0	,,	
,, 17	43	0	0	,,	

Spelter (ordinary).

April 11	35	12	6	inc.	13/9
,, 12	34	15	0	dec.	17 6
,, 13	35	0	0	inc.	5/-
,, 16	35	0	0	No change	
,, 17	34	12	9	dec.	7 6

Lead (English).

April 11	28	15	0	No change	
,, 12	28	5	0	dec.	10/-
,, 13	28	5	0	No change	
,, 16	28	10	0	inc.	5/-
,, 17	28	0	0	dec.	10/-

AVERAGE MONTHLY PRICES OF WEST COAST HEMATITE MIXED NUMBERS.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1885	44 0	44 1	43 2	43 1	42 10	42 6	42 0	42 2	42 1	43 0	43 8	42 11½	
1886	43 3½	42 0	42 0	41 6½	41 2½	40 0	40 0	41 2½	41 6	44 0	44 0	44 9	42 2½
1887	49 6	48 9½	45 6	43 2½	43 6½	44 1	44 0	44 2½	43 5½	41 6	41 9½	45 0	44 6¾
1888	44 4	42 3	42 1½	42 0	41 2½	42 1½	42 6½	44 0	45 8½	44 6	44 6	45 3½	43 4
1889	44 4	45 2	47 3½	48 9½	48 6½	48 7½	50 1½	53 11	55 3	63 6	73 10	73 2	54 4½
1890	76 11½	65 1	63 3	55 1	53 9½	50 11	52 3½	56 4	58 0	58 2	57 5	54 4½	58 5
1891	52 9	50 10	48 11	47 9½	51 5	50 6	50 10	48 4	50 1	49 1½	48 3½	47 8	49 8½
1892	47 4	45 6	46 4½	47 8	49 5	50 4½	49 7½	49 10½	49 10½	48 8½	46 10	46 1½	48 2½
1893	46 0½	45 8	45 11	45 7	44 11	44 9½	44 10	45 3	45 0	44 6	44 7	45 8	45 3
1894	45 3	45 3	45 1½	45 1	43 11	43 11	43 9½	44 2	44 7½	43 7	43 5	43 3	44 3½
1895	42 8	42 5½	42 6	42 10	43 10	43 7½	44 10	45 11	49 11	48 9	47 7½	47 7½	45 2½
1896	47 0	48 9	48 0	48 2½	47 3	47 3	46 10	46 10	47 2	48 5	50 7	50 6	48 1½
1897	51 2	49 10	48 5	47 4	47 9½	48 6	47 0	47 3	47 3	47 0	48 3½	47 11	48 2
1898	48 9	48 10	49 4	49 8½	50 10	50 3½	51 0	52 5	53 11	55 8	57 3	56 10	52 1½
1899	59 1	59 9	57 7	59 6	64 7	70 10½	76 7½	72 2	74 3	75 0	78 1½	73 3	68 5
1900	75 3½	76 10	79 10	84 6	81 4	79 1½	83 4	81 5	79 11	76 10	77 8½	68 4	78 8
1901	60 2	59 0	57 9½	57 6½	57 8	57 4½	57 8	61 0	60 0½	59 9	58 7½	56 7	58 7½
1902	56 1	57 9½	59 3½	59 9	59 10½	60 0	60 0	60 8½	61 5	61 2	59 3	59 0	59 6
1903	58 5	58 8	61 1	59 5	57 10	57 3	56 7	56 3	55 9	54 8	52 4	52 4	56 8½
1904	52 8½	53 1	53 7	54 9	54 2	53 2½	52 9	52 5	52 2½	52 7	53 1	55 11½	53 5½
1905	57 9½	56 9	58 1	58 2	56 4	55 8	55 5½	56 7	61 0	68 9	69 9	70 11½	60 5½
1906	70 4½	65 2½	63 4½	63 9	64 5	64 6	64 1	66 2½	67 3	69 4½	72 4½	78 8½	67 5
1907	77 9	72 11	71 10	73 9	79 9½	76 9	77 9	78 4	75 11	72 9½	68 6	66 7	74 4
1908	62 7	59 1	61 6½	61 6½	61 4	59 1	57 9½	56 11	60 2	59 2	58 5½	57 7	59 7½
1909	51 4	56 5	55 3	56 1	56 4	57 0	56 8	58 0	61 0	61 1½	60 7½	61 4	58 1½
1910	64 0½	64 3½	66 10½	67 6½	66 2½	65 4	64 4½	65 6½	65 2	64 10½	64 6	65 6	65 4½
1911	66 9	66 1	64 10	63 1	62 1	62 0	61 2	62 2	62 1	61 1	61 10	64 0	63 1
1912	67 0	67 0	67 0	69 3	71 9½	72 11	75 9½	79 1½	82 2½	85 0	85 3½	86 6	75 9½
1913	86 6	86 6	86 3	85 0	83 6½	80 10½	78 1	76 10½	72 6	71 0	68 0	65 3	78 4½
1914	64 6	65 4½	65 6	64 11½	64 2½	64 0	64 0	68 11½	74 6½	71 0	65 4½	69 9½	66 10½
1915	78 9	100 6	103 1	113 6	111 9	114 0	116 3	115 2½	113 8½	121 1½	131 9½	139 6½	113 3
1916	135 0	135 0	133 4	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	129 2½	
1917	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1918	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1919	127 6	127 6	127 6	127 6	180 6	184 3	195 4½	204 6	204 6	204 6	204 6	204 6	174 7
1920	224 9	235 0	245 0	275 0	290 0	295 0	295 0	295 0	295 0	295 0	295 0	284 0	284 11½
1921	263 4	228 4	180 0	180 0	180 0	160 0	160 0	157 6	142 0	128 6	121 0	115 6	167 9½
1922	125 0	117 6	115 0	115 0	115 0	115 0	113 1½	104 0	105 0	105 0	106 3	110 0	112 1½

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